RECORD OF DECISION
LF17, SS07/AREA 2, FT01, and LF18/AREA 9
SOUTH MANAGEMENT UNIT
DOVER AIR FORCE BASE, DELAWARE

December 2005

Prepared by:

U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska 68102

and

URS GROUP INC.
200 Orchard Ridge Drive, Suite 101
Gaithersburg, Maryland 20878

Contract No.: DACA45-98-D-0008

Prepared for:

United States Department of the Air Force
Dover Air Force Base
436 CES/CEVR
600 Chevron Avenue
Dover AFB, Delaware 19902-5600

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LIST OF ACRONYMS AND ABBREVIATIONS

AB	Accelerated biodegradation
AMC	Air Mobility Command
ARAR	Applicable or relevant and appropriate requirement
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of concern
COPC	Contaminant of potential concern
DAFB	Dover Air Force Base
DNREC	Department of Natural Resources and Environmental Control
DRGCAP	Delaware Regulations Governing Control of Air Pollution
DRGHSC	Delaware Regulations Governing Hazardous Substance Cleanup
DRGHW	Delaware Regulations Governing Hazardous Waste
EE/CA	Engineering Evaluation/Cost Analysis
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ERP	Environmental Restoration Program
FFA	Federal Facilities Agreement
FS	Feasibility Study
ft	Feet
GMZ	Groundwater management zone
GRW	Groundwater recirculation well
HI	Hazard index
HRC	Hydrogen release compound
HSCA	Hazardous Substance Cleanup Act
LECR	Lifetime excess cancer risk
LUCs	Land use controls
µg/L	Micrograms per liter
MCL	Maximum contaminant level
msl	Mean sea level
NA	Not applicable
NCP	National Contingency Plan
NE	Not evaluated
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NQR	No quantifiable risk
O&M	Operation and maintenance
PAHs	Polycyclic aromatic hydrocarbons
PCE	Tetrachloroethene
PRB	Permeable reactive barrier
RA	Remedial action

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

RAO	Remedial action objective
RBSC	Risk-based screening criterion
RCRA	Resource Conservation and Recovery Act
RD	Remedial design
RfD	Reference dose
RI	Remedial Investigation
ROC	Receptor of concern
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SF	Slope factor
SLERA	Screening Level ERA
SMU	South Management Unit
TBC	To-be-considered
TCE	Trichloroethene
TPH	Total Petroleum Hydrocarbons
TRV	Toxicity reference value
TSV	Toxicity screening value
UCL	Upper confidence limit
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile organic compound

PART I: DECLARATION

1.0 SITE NAME AND LOCATION

Sites LF17, SS07/Area 2, FT01, and LF18/Area 9
South Management Unit
Dover Air Force Base
Kent County, Delaware
CERCLIS ID: DE8570024010

1.1 STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedy for four sites (LF17, SS07/Area 2, FT01, and LF18/Area 9) and associated groundwater contaminant plumes in the South Management Unit (SMU) at Dover Air Force Base (DAFB or Base) in Kent County, Delaware. The U.S. Air Force (USAF), as the lead agency for Superfund activities at DAFB, has prepared this ROD to fulfill the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) 42 USC § 9601 *et seq.*, and the National Oil and Hazardous Substances Pollution Contingency Plan, 40 Code of Federal Regulations (CFR) Part 300 (National Contingency Plan [NCP]). This decision is based on the Administrative Record file for these sites.

The USAF, and the U.S. Environmental Protection Agency (USEPA), Region III, have made the final remedy selection for the sites addressed in this ROD. The State of Delaware, through the Department of Natural Resources and Environmental Control (DNREC), Division of Air and Waste Management, concurs with the selected remedy.

1.2 ASSESSMENT OF THE SITES

Four sites are addressed in this ROD: LF17 is a former landfill used for disposal of general refuse during the 1960s; SS07 is a hazardous waste storage area used to store wastes from industrial shop activities prior to off-Base disposal; FT01 is a former fire training area used during the 1950s and early 1960s; and LF18 is a former landfill used for disposal of general refuse and shop wastes during the 1950s. The Remedial Investigation (RI) for the SMU determined that there are no source materials constituting principal threat wastes at any of these sites. However, as a result of past industrial activities at DAFB, releases of volatile organic compounds (VOCs) have contaminated the groundwater in the surficial aquifer (Columbia Aquifer) at these four sites, and, to a limited extent, polycyclic aromatic hydrocarbons (PAHs) have contaminated soil at LF18. In addition to these individual sites and their associated groundwater contamination, the RI for the SMU identified two multi-source groundwater contaminant plumes that are also being addressed in this ROD. These groundwater plumes are identified as Area 2, for which SS07 is an associated source, and Area 9, for which LF18

is an associated source. Thus, the labels SS07/Area 2 and LF18/Area 9 are used for discussion purposes in this ROD to remain consistent with the RI terminology.

Ecological and human health risks from exposure to contaminants at all four sites were evaluated during the RI for the SMU. There are no ecological risks associated with any of the SMU sites. Risks to human health were evaluated assuming commercial/industrial uses (such as utility or maintenance work) at all four sites, and assuming residential uses at the two sites located at the Base golf course: FT01 and LF18/Area 9. Based on this commercial/industrial use scenario evaluation, which is discussed in greater detail in Section 2.6 of this document, groundwater contamination did not result in risks exceeding established federal comparison criteria. Federal Safe Drinking Water Act maximum contaminant levels (MCLs) were exceeded at the sites, and risks to potential future residential users of groundwater were calculated at the upper end and outside of the "risk range." MCL exceedances in the four groundwater plumes trigger the need for action because there are residential, industrial, and agricultural users of the Columbia Aquifer within the surrounding community. Thus, all four of the SMU sites require action to address groundwater contamination.

In addition to adverse groundwater conditions at all four sites, at Site LF18 the calculated residential risk due to residual soil contamination was found to exceed the federal and state comparison criteria. Thus, action is warranted to address risks from soil at LF18.

The response action selected in this ROD is necessary to protect the public health or welfare from actual releases of hazardous substances into the environment at Sites LF17, SS07/Area 2, FT01, and LF18/Area 9.

1.3 DESCRIPTION OF THE SELECTED REMEDY

Overall Site Strategy: Since its listing on the Superfund National Priorities List in March 1989, DAFB has conducted Basewide RIs and Feasibility Studies (FSs) under the Air Force Environmental Restoration Program (ERP). As part of the overall site cleanup strategy for the Base, DAFB was divided into four management units for the purpose of conducting these studies. The SMU is one of these four management units. There are 10 ERP sites in the SMU, which include the four sites addressed in this ROD, two petroleum exclusion sites (SS06 and OT53) that are being addressed under the State of Delaware's Tank Management Branch, and four sites (LF16, LF19, WP32, and OT55) that will be addressed under a separate ROD for land use controls (LUCs). This ROD selects the final remedy for all media at Sites LF17, SS07/Area 2, FT01, and LF18/Area 9, and addresses all groundwater contamination within the SMU with the exception of petroleum contamination associated with Site OT53.

Remedial Action Objectives (RAOs): RAOs were developed to address the risk associated with soil at Site LF18, the risk associated with groundwater contamination at LF17, SS07/Area 2, and LF18/Area 9, and the adverse environmental conditions associated with off-Base migration of SMU groundwater contamination from all four

sites, including FT01. The RAOs for soil and groundwater contamination at the four SMU sites are discussed in Section 2.7 and are summarized as follows:

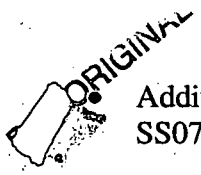
- Reduce concentrations of contaminants of concern (COCs) in the Columbia Aquifer to federal drinking water MCLs.
- Prevent unacceptable exposure to groundwater from the Columbia Aquifer until cleanup levels are achieved.
- Prevent unsafe exposure to soil at LF18 until concentrations of hazardous substances at the site are at levels allowing for unrestricted exposure and unlimited use.

Land Use Control (LUC) Objectives: The Air Force has identified the following LUC performance objectives:

- Prohibit the development and use of Sites SS07 and LF17 for residential housing, elementary or secondary schools, day care centers, and playgrounds until concentrations of hazardous substances at the sites are at levels allowing for unrestricted exposure and unlimited use.
- Prohibit the use of on-Base groundwater from the Columbia Aquifer (first shallow, unconfined aquifer) within the SMU until cleanup levels are met and risks from groundwater use are shown to be reduced to levels that allow for unrestricted exposure and unlimited use.
- Prevent human exposure to, and disturbance of, the landfill contents at LF17 and LF18.
- Prohibit digging and other ground-disturbing activities at LF17, SS07/Area 2, LF18/Area 9, and FT01 that are inconsistent with the objectives listed above and in Section 2.7 of this ROD.
- Maintain the integrity of any current and future remedial or monitoring system.

Major Components of the Selected Remedy: The selected remedy documented in this ROD includes the following major components:

- Injection/Diffusion Accelerated Anaerobic Biodegradation treatment of contaminated groundwater in the upgradient source area of the Area 2 plume, in the vicinity of Site SS07. This remedy involves injection of an organic carbon material into the aquifer to enhance anaerobic (low oxygen) conditions to stimulate naturally-occurring bacteria to biodegrade organic contaminants.
- Natural Attenuation (with monitoring) to reduce groundwater contamination at LF17, LF18/Area 9, FT01, and the remainder of the SS07/Area 2 plume that is not treated via accelerated anaerobic biodegradation.
- Periodic monitoring of groundwater conditions to assess remedy performance.
- LUCs, which are discussed in more detail below.
- Additional sampling (during remedial design) to better define the downgradient edge of the LF17 plume.
- Additional sampling (during remedial design) in the northeastern area of LF18/Area 9 and source treatment if a defined source is identified.



Additional sampling (during remedial design) of the northeastern area of SS07/Area 2 and source treatment if a defined source is identified.

The LUCs component of the selected remedy includes the following provisions:

- Restriction of land use at Sites SS07 and LF17 to industrial purposes, with on-site day-care centers and recreation areas prohibited.
- Maintain the turf cover over Site LF18.
- Prohibit on-Base groundwater use from the Columbia Aquifer in the SMU until cleanup levels are achieved.
- Prohibit digging and other ground-disturbing activities at LF17, SS07/Area 2, LF18/Area 9, and FT01 that are inconsistent with the objectives listed above and in Section 2.7 of this ROD.
- Use of the Base General Plan as the implementation plan for LUCs. DAFB will update the Base General Plan to include the LUC requirements for the four sites included in this ROD.
- Compliance with Air Force administrative procedures for review and prior approval by environmental personnel of proposed construction or subsurface soil disturbing activities (Base digging permit process).
- Submittal of survey plats to the Kent County recording authority, USEPA, and DNREC indicating the location and dimensions of landfill Sites LF17 and LF18.
- Visual site inspections and reporting on at least an annual basis to verify compliance with LUC requirements, and prompt notification to regulators of any LUC deficiencies.
- Compliance with the notification requirements of CERCLA Section 120(h) prior to any transfer or sale of property at the site.
- Enforcement of well installation restrictions on-Base and at nearby off-Base properties per the Groundwater Management Zone (GMZ) established by Delaware DNREC.
- Maintain the integrity of any current and future remedial or monitoring system.

The Air Force, represented by the 436th Airlift Wing Commander at DAFB, is responsible for implementing, monitoring, reporting on, and enforcing these LUCs with the exception of the GMZ which is the responsibility of DNREC. All of the use and activity restrictions and controls set forth in this ROD shall remain in place until concentrations of hazardous substances at the sites are shown to be at levels allowing for unrestricted exposure and unlimited use. Section 2.8.1.9 provides a detailed description of each of the above listed LUCs.

1.4 STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State applicable or relevant and appropriate requirements (ARARs), and is cost-effective. The remedy for the SMU sites uses permanent solutions and alternative treatment technologies to the maximum extent possible. This remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces the

toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment). The remedy will prevent or control human exposure to contaminated media through implementation of LUCs. Because this remedy will result in hazardous substances remaining on-site above levels that allow for unrestricted exposure and unlimited use, a statutory review will be conducted within five years after initiation of the remedy to ensure that the remedy is protective of human health and the environment.

1.5 ROD DATA CERTIFICATION CHECKLIST

The following information appears in the Decision Summary section (Part II) of this ROD. Additional information regarding the SMU sites can be found in the DAFB Administrative Record.

1. COCs are summarized with their maximum detected concentrations and detection frequencies in Table 2.
2. Baseline human health risks due to the COCs are summarized in Table 4.
3. Results of the Basewide Ecological Risk Assessment (ERA) are discussed in Section 2.6.2.
4. The RAOs established for the SMU sites are discussed in Section 2.7.
5. Current and reasonably anticipated future land and groundwater uses are discussed in Section 2.5.
6. Principal threat wastes are discussed in Section 2.10.
7. Potential land and groundwater uses that will be available as a result of the selected remedy are discussed in Section 2.11.4.
8. Section 2.11.3 and Table 12 summarize the estimated capital, annual operation and maintenance, total present worth costs; discount rate; and the number of years over which the remedy costs are projected.
9. The key factors that led to the selection of the remedy are discussed in Section 2.9 and summarized in Section 2.11.

1.6 AUTHORIZING SIGNATURES AND SUPPORT AGENCY CONCURRENCE

AUTHORIZING SIGNATURES

This signature sheet documents the agreement between the United States Air Force and the United States Environmental Protection Agency on the Record of Decision for the South Management Unit, Dover Air Force Base, Delaware.

ABRAHAM FERDAS — Date 1/4/06
Director
Hazardous Site Cleanup Division
U.S. Environmental Protection Agency, Region III

SAMUEL D. COX, Colonel, USAF — Date 15 Dec '05
Commander, 436th Airlift Wing
Dover AFB, DE

SUPPORT AGENCY CONCURRENCE

The Delaware Department of Natural Resources and Environmental Control has reviewed this Record of Decision for the South Management Unit and the materials on which it is based, and concurs with the selected remedy.

KATHLEEN STILLER BANNING — Date 12/20/05
Environmental Program Manager
Site Investigation and Restoration Branch
Delaware Department of Natural Resources and
Environmental Control

PART II: DECISION SUMMARY

ORIGINAL

2.0 SITE NAMES, LOCATION, AND DESCRIPTION

Site Names: LF17, Landfill 17
SS07, Hazardous Waste Storage Area, Buildings 1305 and 1306
FT01, Fire Training Area One, Golf Course
LF18, Landfill 18, Golf Course
Area 2, Multi-Source Groundwater Plume Associated with SS07
Area 9, Multi-Source Groundwater Plume Associated with LF18

Location: South Management Unit (SMU), Dover Air Force Base, Delaware

National Superfund Electronic Database Identification Number: DE8570024010

Lead Agency for CERCLA Activities at DAFB: United States Air Force (USAF)

Lead Regulatory Agency: United States Environmental Protection Agency (USEPA) Region III

Support Agency: Delaware Department of Natural Resources and Environmental Control (DNREC)

Funding Source: Air Force Environmental Restoration Account

Site Type: LF17 – Landfill
SS07 – Industrial Facility Surface Spill
FT01 – Fire Training Area
LF18 – Landfill

Site Description: DAFB is located in Kent County, Delaware, about 3.5 miles southeast of the city of Dover (Figure 1, inset map) and is bounded to the southwest by the St. Jones River. DAFB encompasses approximately 4,000 acres of land, including annexes, easements, and leased property. The surrounding area is primarily cropland and wetlands with smaller residential, industrial, and commercial areas along the major highways. A large gravel quarry is located next to a portion of the Base's southwest boundary. DAFB began operations in December 1941. Since then, various military services have operated out of DAFB. The present host organization is the 436th Airlift Wing, a part of the USAF Air Mobility Command (AMC). Its mission is to provide global airlift capabilities, including transport of cargo, troops, equipment, and relief supplies. The Base also serves as the joint services port mortuary, designed to accept casualties in the event of war.

On March 13, 1989, DAFB was placed on the USEPA National Priorities List (NPL) for Superfund. In August 1989, the USAF entered into a Federal Facility Agreement (FFA)

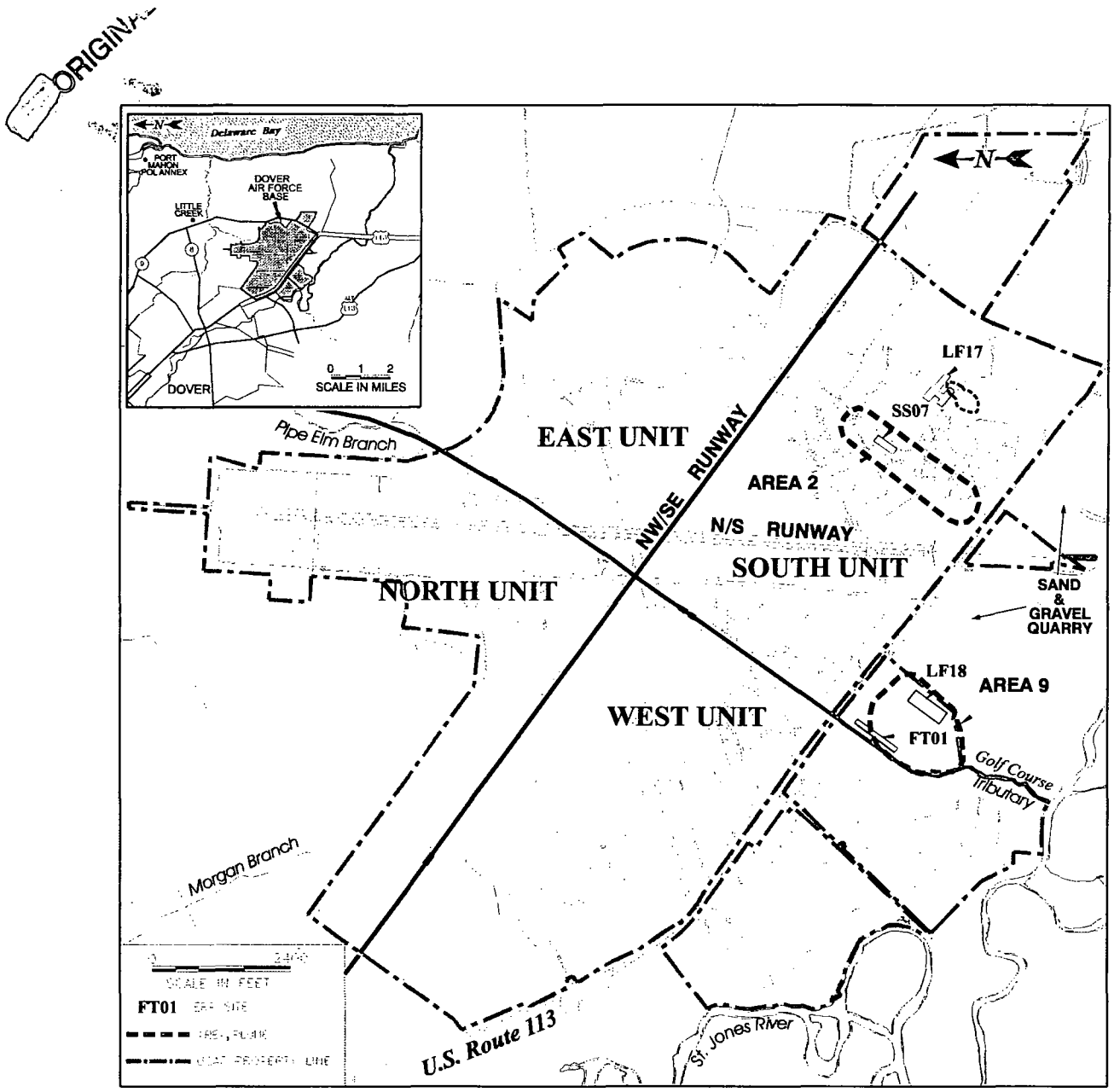


Figure 1. Location of SMU Sites and Areas

with USEPA Region III and the State of Delaware to facilitate environmental cleanup activities at DAFB. Subsequently, investigations were conducted under the Air Force ERP (formerly the Installation Restoration Program).

The sites addressed in this ROD, LF17, SS07/Area 2, FT01, and LF18/Area 9, are located in the southern portion of the Base, in the SMU (Figure 1). This unit is one of four management units (North, South, East, and West) into which the Base has been divided for the purpose of conducting the Basewide RI. The SMU contains 10 ERP sites, including the four sites addressed in this ROD, two petroleum exclusion sites (SS06 and OT53) that are being addressed under the State of Delaware's Tank Management Branch, and four other sites (LF16, LF19, WP32, and OT55) that are being addressed under a separate ROD for LUCs. The SMU is split into two sections by U.S. Route 113. The portion of the SMU northeast of U.S. Route 113 is in the fenced industrial area of the Base; Sites LF17 and SS07/Area 2 are in this industrial area of the SMU. The portion of the SMU southwest of U.S. Route 113, where Sites FT01 and LF18/Area 9 are located, encompasses part of the Base golf course in the residential area of the Base.

Site LF17 is a former landfill of approximately 3.5 acres, currently maintained as an open grassy field. SS07 is a release site associated with a hazardous waste storage area at Buildings 1305 and 1306. FT01 is a former fire training area, and LF18 is a former landfill, both of which are located on what is now the Base golf course. Area 2 and Area 9 are multi-source groundwater plumes most closely associated with ERP Sites SS07 and LF18, respectively.

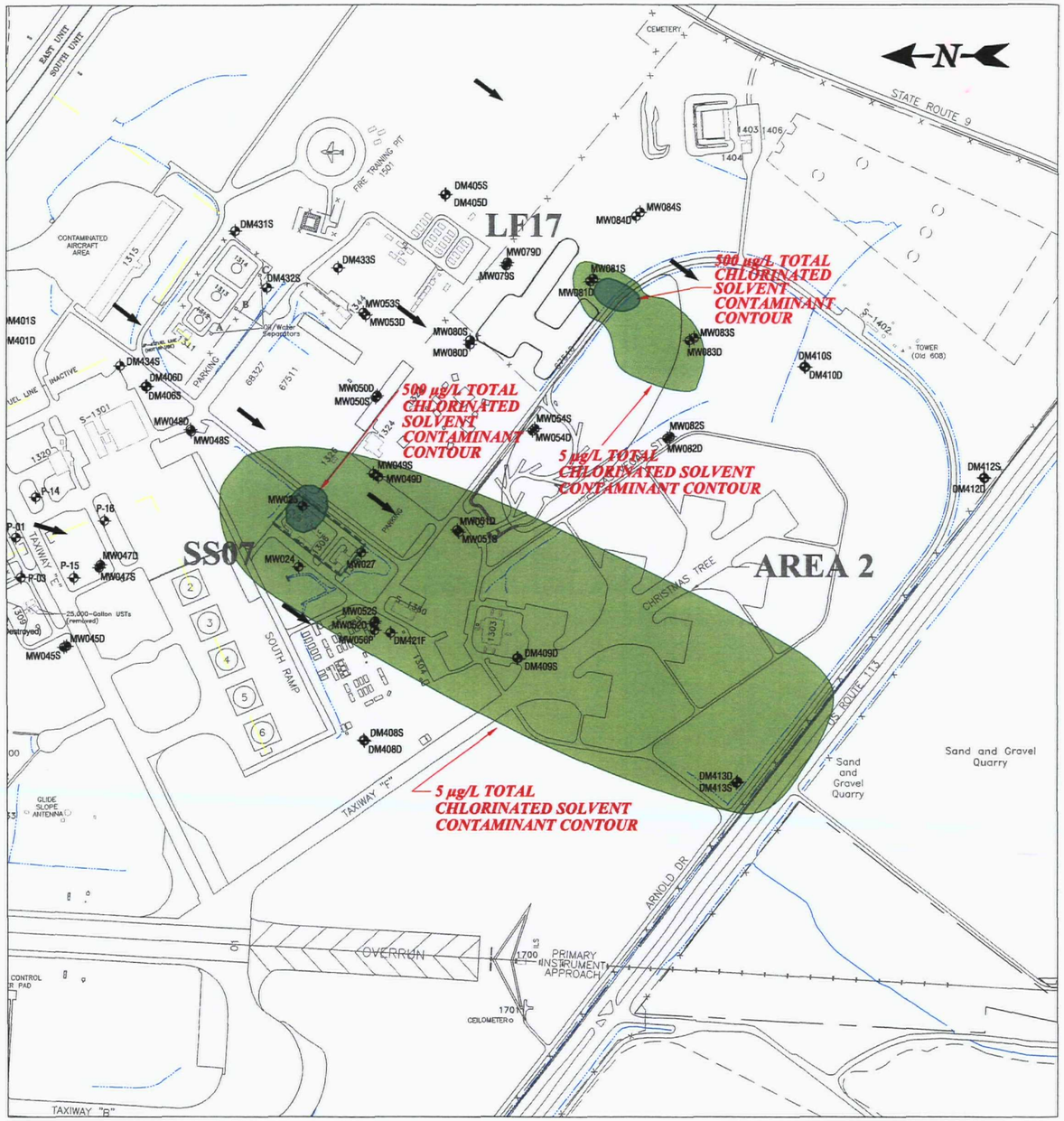
2.1 SITE HISTORY AND ENFORCEMENT ACTIVITIES

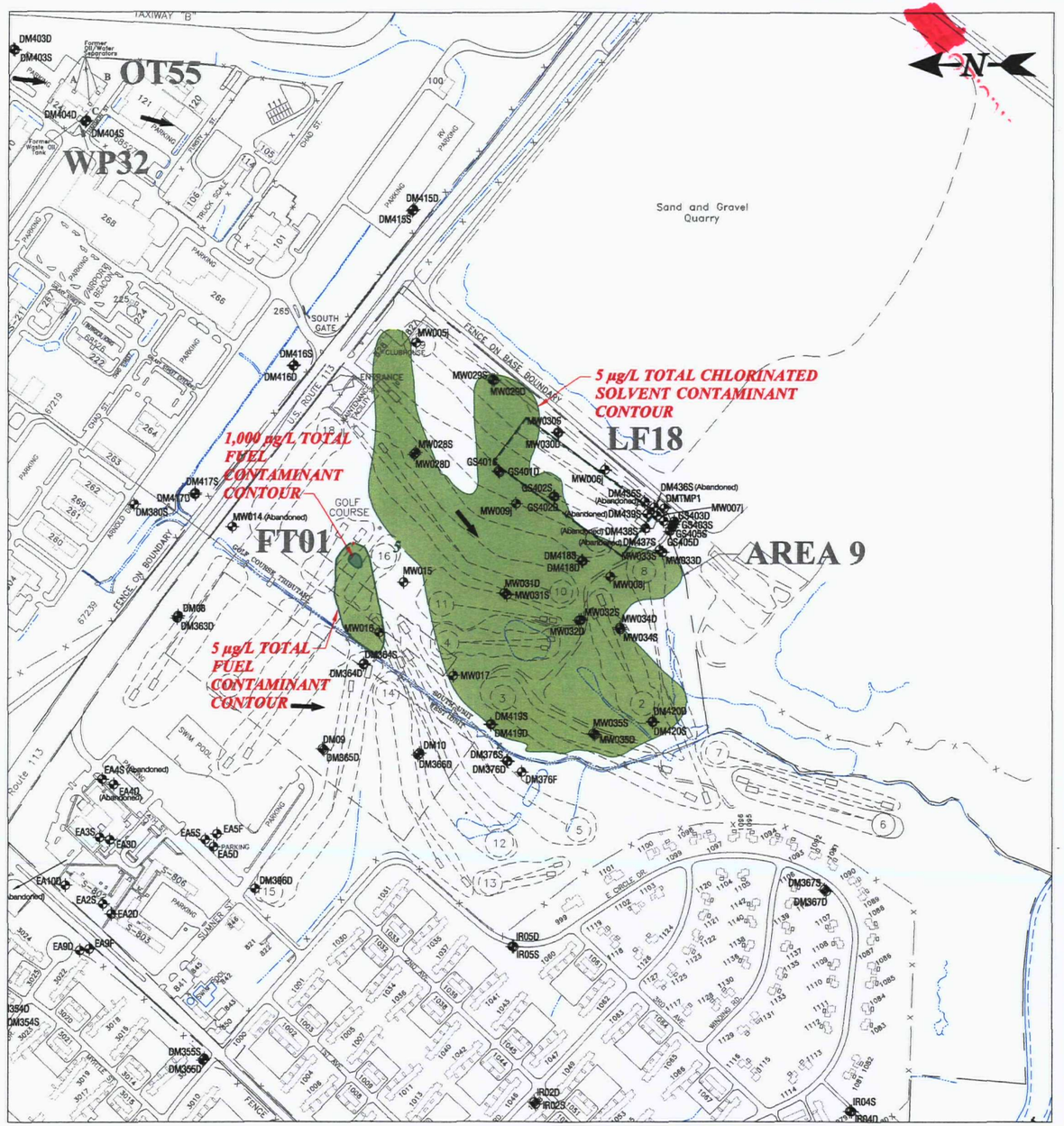
2.1.1 LF17

LF17 is a 3.5-acre area that was used as a trench-and-fill landfill during the 1960s for disposal of general refuse (Figure 2). The trenches were dug to the depth of the water table, approximately 8 to 10 feet below ground surface (ft bgs). The landfill was covered with several feet of soil and seeded with grass after disposal activities ceased. It has been maintained ever since as an open grassy field. Groundwater contamination, consisting primarily of solvents that were historically used in aircraft maintenance activities, is present at Site LF17. RI field work was accomplished during the early 1990s (U.S. Army Corps of Engineers [USACE], 1997), and an FS for the SMU was finalized in January 2005 (USACE, 2005a). To date, no CERCLA remedial actions have been conducted at the site. There have been no CERCLA or other enforcement activities associated with Site LF17.

2.1.2 SS07/Area 2

SS07 (Buildings 1305/1306; Figure 2) has been used as an intermediate hazardous waste storage area since 1981. Industrial activities have been conducted at this facility since the 1940s. At the present time, wastes derived from various industrial shop activities are stored there prior to off-Base disposal. Drums of waste oils, hydraulic fluids, and other





LEGEND:

- MW031S Monitoring Well
- Direction of Groundwater Flow

0 600
SCALE IN FEET

CLIENT	DOVER AFB			
PROJ	SMU ROD			
REVISION NO	0	DES BY	LS	12/06/05
SCALE		DR BY	MS	12/06/05
FILE		CHK BY	LS	12/06/05

TITLE: SITE MAP
SMU, DAFB

URS

PROJ NO

FIGURE 2

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wastes are stored inside the facility on a bermed concrete floor. RI field work was accomplished during the early 1990s (USACE, 1997), and an FS for the SMU was finalized in January 2005 (USACE, 2005a). Although there are no documented releases of contaminants at SS07, signs of surface spills were evident outside the facility during the RI.

Area 2 is the groundwater contaminant plume associated with Site SS07 and other nearby sources, including upgradient petroleum exclusion Site OT53. Solvents that were historically used in aircraft maintenance activities and petroleum are the primary COCs within the Area 2 groundwater plume. The Area 2 groundwater plume flows southwest to the Base boundary at U.S. Route 113 (Figure 2). A privately owned sand and gravel quarry is located directly across U.S. Route 113 downgradient from the Area 2 plume. The quarry has large dredged ponds dug into the upper portion of the Columbia Aquifer (water table aquifer), and quarry operators moves the pond water from pond to pond in their processing operations. However, the quarry operators do not use the Columbia Aquifer as a potable water source. Beyond the quarry to the southwest is the St. Jones River.

To date, no CERCLA remedial actions have been conducted at SS07/Area 2, and there have been no CERCLA or other enforcement activities associated with the site.

2.1.3 FT01

FT01 is a former fire training area used during the 1950s and early 1960s (Figure 2). The site is approximately 900 ft long by 50 ft wide, and is located on the Base golf course next to a drainage tributary. Waste oils, waste solvents, paint thinners, and jet fuel were stored on site and used for fire training activities. Operations at the site consisted of spreading approximately 1,000 gallons of waste fuels and flammable liquids on a water-saturated area, igniting the material, and using protein foams to extinguish the flames. The site was covered over with soil and grass when the Base golf course was constructed during the 1960s. RI field work was accomplished during the early 1990s (USACE, 1997). In 1994, maintenance workers discovered several buried drums while installing a sprinkler system. In March 1998, a removal action was conducted during which three crushed 55-gallon drums and associated oil-contaminated soil were removed and disposed of at an off-site facility permitted to accept such waste. An FS for the SMU was finalized in January 2005 (USACE, 2005a). There is residual fuel and solvent contamination in groundwater at Site FT01. There have been no CERCLA or other enforcement activities associated with the site.

2.1.4 LF18/Area 9

LF18 is a former landfill encompassing approximately 3 acres at what is now the southeastern edge of the Base golf course (Figure 2). Four trenches were filled with general refuse, drums of waste solvents, and other shop wastes during the mid-1950s. The depth of the trenches reportedly extended into the water table. After disposal activities ceased, the site was covered with several feet of soil and seeded with grass. The Base golf course was constructed over the site during the 1960s. The privately

owned sand and gravel quarry is located immediately to the southeast of Site LF18. RI field work was accomplished during the early 1990s (USACE, 1997). In addition to evaluating soil and groundwater at LF18, the RI also evaluated surface water and sediment in the golf course tributary, a ditch southwest of LF18 that drains surface water from the southwest side of the Base. A remedial action for soil was performed at LF18 in 1997-1998 based on a ROD signed in 1996 (USAF, 1996). The RAO was to reduce contaminant concentrations in soil to the Delaware regulatory level of 1,000 milligrams per kilogram (mg/kg) total petroleum hydrocarbons (TPH) and 10 mg/kg total benzene, toluene, ethylbenzene, and xylenes (BTEX). Approximately 1,900 tons of waste-oil contaminated soil were removed and taken off site for treatment and disposal. Four buried 55-gallon drums containing an oily petroleum substance were removed from the excavation, and six 55-gallon drums of free phase oil were vacuumed from the excavation (USACE, 1999). The drums and oil were disposed of at an off-site facility permitted to accept such waste. Groundwater monitoring for petroleum contaminants was conducted for several years at the downgradient end of the excavation area. This monitoring was terminated in 2003 after petroleum hydrocarbon contaminant levels in the vicinity of the excavated area declined to levels below federal MCLs.

Area 9 is a groundwater contaminant plume associated with Site LF18 and other sources on the Base golf course (Figure 2). COCs within the Area 9 plume consist of solvents that were historically used in aircraft maintenance activities. Based on the flow pattern of the Area 9 plume, it is likely that, in addition to Site LF18, several other sources contributed to the contaminant plume. However, no soil contamination has been found to confirm the existence of any other sources, likely because these probable sources are so old (pre-1960). The chlorinated solvent source area associated with LF18 has waned significantly since the soil remedial action was conducted at that site. Currently the Area 9 groundwater plume consists of relatively low level contamination covering a wide area, with no known existing source areas. The Area 9 groundwater plume flows in a west-southwest direction toward a drainage tributary that bisects the Base golf course. This golf course tributary discharges into the St. Jones River. There have been no CERCLA or other enforcement activities associated with LF18/Area 9.

2.2 COMMUNITY PARTICIPATION

DAFB actively encourages public participation at all phases of environmental restoration work, and operates under a Community Relations Plan that is periodically updated. In accordance with NCP §300.430(f)(3), the Proposed Plan for the DAFB SMU sites addressed in this ROD and supporting documentation were made available to the public in February 2005. They can be found in the Administrative Record file and the Information Repository maintained at the 436th Civil Engineer Squadron DAFB and at the Dover Public Library, 45 S. State Street, Dover, DE. The notice of availability for the proposed plan was published in the Delaware State News on February 6, 2005. A public comment period was held from February 13 to March 14, 2005. The notice included information telling community members how to request a public meeting pertaining to the proposed plan. No questions or comments from the public were received, nor was a

public meeting requested. This is documented in Part III, the Responsiveness Summary in this ROD.

2.3 SCOPE AND ROLE OF OPERABLE UNIT OR RESPONSE ACTION

As discussed in Section 2.0, for purposes of conducting the RI/FS, DAFB was divided into four management units, and the sites addressed in this ROD are in the SMU. There are ten ERP sites located in the SMU. No action is required to address surface water or sediment at any of the SMU sites. For soil and groundwater, the following is a summary of the cleanup strategy for the SMU, including past actions, actions addressed in this ROD, and future planned actions. Items highlighted in bold are addressed in this ROD.

Past Actions at SMU Sites

- Two of the ten SMU sites (SS06 and OT53) are classified under the CERCLA petroleum exclusion and are being addressed under the State of Delaware's Tank Management Branch per the Delaware Regulations Governing Underground Storage Tank Systems. The State of Delaware issued a no further action letter for SS06 in March 2000. For Site OT53, a Corrective Action Plan (CAP) was approved by the State in 1997. Site OT53 contributes petroleum contaminants to the Area 2 co-mingled groundwater plume. These petroleum contaminants are being addressed per the CAP and are therefore not addressed in this ROD. In 1998 monitored natural attenuation was implemented as the remedy for petroleum contamination in groundwater at OT53. Groundwater monitoring for natural attenuation is ongoing at OT53.

- In March 1998, a removal action was conducted at FT01 during which three crushed 55-gallon drums and associated oil-contaminated soil were removed and disposed of at an off-site facility permitted to accept such waste.

- Of the remaining SMU sites, only one site, LF18, was found to require remedial action for soil contamination. At LF18, an area of free-phase oily waste was discovered during the RI at the southwest edge of the landfill. A ROD for soil excavation, treatment and disposal was signed in 1996, to remove this source area that was impacting groundwater. As discussed in Section 2.1.4, the soil remedy was executed in 1997-1998, and subsequent groundwater monitoring confirmed that RAOs were achieved. This was documented in a Five-Year Review in 2003 (BWXT, 2003).

Actions Addressed in this ROD

The remedy selected in this ROD addresses all media and all response actions required at Sites LF17, SS07/Area 2, FT01, and LF18/Area 9. No action is required for surface water or sediment at these sites. The following is a summary of the response actions selected in this ROD for each of these sites.

- **LF17. Natural attenuation to address groundwater contamination at LF17, with sampling to better define the downgradient edge of the plume, and periodic monitoring. LUCs to control exposure to soil and prevent exposure to groundwater at the site.**

- **SS07/Area 2. Accelerated anaerobic bioremediation to treat the source area of groundwater contamination at SS07, with sampling to better define the upgradient area of SS07/Area 2, and source treatment if a defined source is located. Natural attenuation to address the remainder of the Area 2 plume. Periodic monitoring of the entire plume. LUCs to control exposure to soil and prevent exposure to groundwater.**

- **FT01. Natural attenuation to address groundwater contamination at this site. LUCs to prevent exposure to groundwater. No further action is required for soil at FT01.**

- **LF18/Area 9. Natural attenuation to address groundwater contamination at LF18/Area 9, with sampling to better define the upgradient portion of Area 9 and source treatment if a defined source is located. Periodic groundwater monitoring. LUCs to prevent exposure to soil and groundwater.**

Future Actions for SMU Sites

- Four of the ten SMU sites (LF16, LF19, WP32, and OT55) were found to have no human health or ecological risks associated with them as documented in the RI (USACE, 1997) and the Basewide ERA (USACE, 2000). However, the human health risk assessment was based on assumptions that land use at the sites would remain industrial. Therefore, to ensure the permanence and reliability of these land use assumptions, and thus ensure the protection of human health, LUCs are being proposed for these sites. DAFB plans to include all four of these sites in a single ROD for implementation of LUCs at multiple sites across the Base.

2.4 SITE CHARACTERISTICS

2.4.1 Conceptual Site Models

LF17. In the past, general refuse was placed in surface trenches at this site and then covered with soil and grass turf. Although much of the material was probably benign, over time one small area of the landfill (near its southern corner) released chlorinated solvents into the surrounding subsurface soil. The solvents migrated downward through the soil column where they encountered the water table aquifer. The solvents were transported as a dissolved phase with the natural downgradient flow of groundwater, forming a small plume. Based on the groundwater chemistry observed at this site, the solvents appear to be naturally attenuating through anaerobic biodegradation. According to the most recent groundwater sampling data, the contaminant plume related to this site does not extend to the Base boundary.

SS07/Area 2. Industrial activities at SS07, including the handling of hazardous wastes, appear to have release chlorinated solvents into the environment. The analytical soil data for the site does not reveal an isolated release point although it is believed to be somewhere near well MW25 where contaminants were found in the shallow groundwater. These contaminants migrate in a dissolved phase with the natural flow of groundwater, which is to the southwest and vertically downward. Thus, the contaminants enter the shallow water table near the area around MW25 and are transported downgradient within the aquifer. Groundwater sampling in the same area around MW25 also found contaminants in the deeper portion of the aquifer, which suggests a potential source upgradient of SS07. The commingling contaminants from these sources form a long, relatively narrow plume that has been labeled Area 2. Although evidence of anaerobic biodegradation has been observed within this plume, degradation has not been sufficient to keep the plume from reaching the Base boundary. The groundwater plume is likely discharging off-Base to the surface waters in an adjacent quarry pond. The pond does not supply potable water to the quarry operation.

FT01. Flammable materials (solvents and fuel) were spread on the ground surface and ignited at this site for fire training activities. Although much of the material was likely burned during the training exercises, some residual contaminants could have remained in site soil and been transported via surface runoff into the nearby golf course tributary. Sampling of the tributary's sediment and surface water has revealed no lasting effects from the training activities on these media. Residual contaminants in soil appear to have had a minor effect on groundwater quality at the site. A small, shallow plume of fuel contaminants is present at the site. Additionally, a few chlorinated solvents were detected in site wells; however, it appears that they are more likely related to the nearby Area 9 plume (discussed next). The groundwater plume is discharging on-Base to the surface waters of the golf course tributary.

LF18/Area 9. At this site, a series of trenches were filled with debris including waste solvents and other shop wastes. The material was covered with soil and later became part of the golf course. Primarily fuel (and minor solvent) contaminants were released at one end of the trenches, affecting subsurface soil and groundwater. Because the material was buried, overland transport of contamination was not an issue at this site. The fuel source has undergone a successful soil cleanup action, which has improved groundwater quality in this area. However, residual soil contaminants appear to exist in other parts of the site. The pattern of chlorinated solvents in groundwater at the golf course suggests that LF18 is not the only potential source, although site soil data do not identify an alternative one. The overall groundwater plume, which doesn't include Site FT01, is designated Area 9. In general, the plume flows towards the golf course tributary, the nearest discharge point. At times, dewatering pumping at the adjacent sand and gravel quarry has temporarily influenced local groundwater flow patterns. Thus, the Area 9 plume primarily discharges to the golf course tributary although occasional discharge to the quarry pond is possible depending on the operation of the quarry dewatering wells. The pond does not supply potable water to the quarry operation.

2.4.2 Topographical and Hydrogeologic Information

The surface topography of DAFB is relatively flat, with elevations ranging from 10 to 30 ft above mean sea level (msl). Areas of lower elevation (10 ft above msl or less) are located adjacent to the St. Jones River and Pipe Elm Branch (a tributary to the Little River). Elevations of 30 or more ft above msl occur in the housing area, which is located south of U.S. Route 113, in the western portion of the Base. Surface water runoff is handled by an extensive storm drainage network of open ditches and pipe culverts. The storm drainage network discharges primarily to the St. Jones River, the Pipe Elm Branch, and the Morgan Branch. Surface water in the southern portion of the Base (the SMU) is directed to the St. Jones River. The golf course tributary is a drainage ditch that bisects the golf course and is located at the northwestern boundary of the SMU. The golf course tributary channels stormwater runoff from the southwest side of the Base, including the golf course area, and discharges into the St. Jones River.

There are four groundwater aquifers underlying DAFB. They are, in descending order: the Columbia, the Frederica, the Cheswold, and the Piney Point. The water table aquifer at DAFB is the Columbia Aquifer. The water table is usually encountered at 10 to 15 ft bgs, but varies according to surface topography from 30 ft bgs to within a few feet of the ground surface. The Pleistocene sediments occupied by the Columbia Aquifer underlying DAFB consist of medium- to coarse-grained sand with gravelly sand, gravel, silt, and clay lenses common throughout. The upper portion of the Columbia Formation is finer grained and contains more silt and clay lenses than the deeper portions. The saturated thickness of the Columbia Aquifer ranges from 15 to 20 ft in the northern portion of the Base to 70 ft in the southeastern portion. The deeper portion of the Columbia Formation is typically fine- to coarse-grained sand with occasional lenses of fine to medium sand and discontinuous gravel lenses interpreted as channel lag deposits. The overall trend from coarser to finer material represents a change in depositional environment from higher to lower energy.

Underlying the Columbia Aquifer is a dense Miocene clay layer known as the Calvert Formation. It is approximately 20 ft thick. The contact between the Columbia and Calvert Formations forms a hummocky erosional surface. The Upper Confining Unit of the Calvert Formation generally consists of gray to dark gray, firm, dense clay, with thin laminations of silt and fine sand. It separates the Columbia Aquifer from the Frederica Aquifer, acting as a barrier to prevent the vertical migration of contaminants from the Columbia Aquifer to the Frederica Aquifer. In one localized area near the center of the Base, the confining unit appears to be thin or missing. The Frederica Aquifer is the upper sand unit of the Calvert Formation and underlies the upper clay and silt unit. The potentiometric surface of the Frederica Aquifer is generally 4 to 6 ft lower than the groundwater levels of the Columbia Aquifer except near groundwater discharge points such as the St. Jones River where the levels are reversed. Below the Frederica Aquifer, the next two deeper aquifers are the Cheswold and Piney Point.

2.4.3 Ecology

DAFB is located on a broad, low coastal plain in the Atlantic Coastal Plain Physiographic Province know as the Delmarva Peninsula. This area is characterized by low desiccated (dry) hills and sandy plains and includes mature streams and wetland areas. Ecological habitat at DAFB is comprised of open grassy fields and areas adjacent to three main surface drainages: Pipe Elm Branch, St. Jones River, and Morgan Branch. These areas, where not covered by parking lots, buildings, or regularly mown grass (including the Base golf course), consist of low seral (dry, withered) vegetation, non-tidal emergent wetlands, mesic (moderate moisture) and wet hardwood forests, tidal swamp forests, and freshwater and brackish marshes. The best quality habitats (and the least disturbed) are found along the Pipe Elm Branch drainage in the East Management Unit. The ecological habitat in the SMU consists mainly of regularly mown grass.

2.4.4 Archaeological or Historical Significance

There are no areas of archaeological of historical significance at any of the SMU sites.

2.4.5 Sampling Strategy

Several environmental investigations were conducted at Sites LF17, SS07/Area 2, FT01, and LF18/Area 9 prior to the Basewide RI (see Attachment 1 for reference list). However, the Basewide RI is the most comprehensive evaluation of the entire SMU. These initial investigations and the RI were documented in the following reports:

- *USAF Installation Restoration Program – Dover AFB, Delaware, Phase II – Stage I Confirmation/Quantification* (Science Applications International Corporation (SAIC), 1986). Surface soil and groundwater sampling at SS07; groundwater and surface water sampling at FT01; groundwater sampling at LF18.

- *Installation Restoration Program – Stage 2 Report, Dover Air Force Base, Delaware* (SAIC, 1989). Groundwater sampling at LF17; soil gas survey, soil, sediment, surface water, and groundwater sampling at SS07; soil gas survey, geophysical survey, surface water, sediment, and groundwater sampling at LF18.

- *Site Investigation for Fire Training Area 1 at Site FT-1* (Hazardous Waste Remedial Actions Program (HAZWRAP), 1991). Sediment and soil sampling at FT01.

- *Ecological Risk Assessment, Phase I: Site Characterization, Dover AFB, Dover, Delaware* (HAZWRAP, 1993). Surface water and sediment sampling at SS07; surface water and sediment sampling at LF18.

- *Basewide Remedial Investigation, Dover Air Force Base, Delaware[South Management Unit, Volumes I – IV]* (USACE, 1997). Soil and groundwater sampling at LF17; soil and groundwater sampling at SS07/Area 2; soil and

groundwater sampling at FT01; surface water, sediment, soil, and groundwater sampling at LF18; two test pits excavated in the LF18 landfill and sampled; sampling of floating product (waste oil) from two wells at LF18.

Environmental problems were not found in surface water or sediments in the SMU during any of the above listed investigations. Only two sites (LF18 and FT01) were found to warrant soil actions. At LF18, an area of free phase waste oil was identified during the RI. Therefore, in 1996, an Engineering Evaluation and Cost Analysis (EE/CA) was performed to define the extent of the oil-impacted area at LF18 and evaluate remedial alternatives. Based on the EE/CA results, a soil remedial action was accomplished at LF18 as previously discussed in Section 2.1.4. The LF18 remedial action and initial confirmatory sampling was documented in a post-excavation report. Additional soil sampling was accomplished during the summer and fall of 1998 to confirm that all of the oil-impacted soil had been removed. Several confirmation samples taken at the LF18 excavation contained levels of petroleum contaminants above the RAO for the soil action (1,000 mg/kg TPH and 10 mg/kg BTEX). However, these samples were taken at or below the water table elevation and may have been influenced by groundwater contamination. Therefore, in consultation with the USEPA and DNREC, DAFB initiated groundwater monitoring in the vicinity of the excavation area. Post-excavation groundwater concentrations for the COCs declined to below federal MCLs within four years of the remedial action, indicating that the action had been successful. Sampling and remedial activities relative to the LF18 oil-impacted area are documented in the following reports:

- *Final Engineering Evaluation and Cost Analysis Site LF18* (USACE, 1996). Investigation to delineate the extent of free product; viscosity and density analysis of free product sample; geologic profiles to evaluate fill material; soil sampling; vadose zone permeability testing.

- *Post Excavation Report, Site LF18, Dover Air Force Base, Delaware* (USACE, 1999). Documentation of soil remedial action and confirmation soil sampling.

- *Data Letter for LF18 Soil Samples, Summer/Fall 1998* (U.S. Geological Survey (USGS), 1998). Confirmation soil sampling at LF18 excavation area.

- *Data Letter for LF18 Groundwater Samples, April 2002* (USGS, 2002). Groundwater monitoring at LF18 excavation area.

The second soil action accomplished in the SMU was a small removal action at Site FT01. In 1994, Base maintenance workers discovered buried drums at FT01 during installation of a sprinkler system on the golf course. DAFB removed three buried 55-gallon drums and associated contaminated soil in 1998 as described in Section 2.1.3. Subsequently, groundwater sampling was accomplished to determine impacts from the buried drums as documented in the following:

- *Data Letter for FT01 Groundwater Samples, Summer 1998* (USGS, 1999).

For groundwater, the SMU RI identified several chlorinated solvent plumes within the Columbia Aquifer (water table), and these are the primary environmental concern. The plumes that appeared to have multiple sources were designated as Area 2 and Area 9 in the RI report. A smaller plume (predominantly chlorinated solvents) was associated with individual ERP site LF17, and a combination of chlorinated solvents and petroleum contaminants was found in groundwater at FT01. Figure 2 shows the site locations, monitoring wells used to sample groundwater, and approximate areas of the contaminant plumes. During the course of preparing the FS for the SMU sites, a two-phased comprehensive groundwater study was conducted at the SMU sites during 2001-2002 in response to regulator comments. The purpose of this study was to better delineate the SMU groundwater plumes, evaluate contaminant degradation rates, and evaluate natural attenuation as a potential remedy. The data from this investigation were documented in an addendum to the SMU FS report, and used to support conclusions and recommendations in the SMU FS report:

- *Feasibility Study [and Addendum: Plume Delineation and Assessment of Natural Attenuation], South Management Unit, Dover Air Force Base, Delaware* (USACE, 2005a)

2.4.6 Nature And Extent of Contamination

Data collected for the RI were combined with data from the previous studies to provide the basis for defining the nature and extent of the contamination and risk assessments for the SMU sites. As mentioned in Section 2.4.5, additional data were later collected in 1998 at the LF18 and FT01 soil action locations, and in 2001-2002 at all the SMU groundwater plumes to support the recommendations in the SMU FS. Brief summaries of the contamination assessment findings for each site are provided below. There were no COCs found in surface water or sediment in the SMU.

2.4.6.1 LF17

Soil samples collected from the LF17 landfill during the RI were found to contain primarily petroleum-related contaminants and some pesticides. However, none of the soil contaminants were found to cause a risk to potential workers in the area under the commercial/industrial exposure scenarios evaluated. Of the contaminants detected in soil, only benzene was found to be a concern in groundwater. Since benzene was present at very low concentrations in only two soil samples, it is unlikely that residual contaminants in soil pose a current threat of leaching to groundwater at LF17.

A plume of groundwater contamination, consisting primarily of chlorinated solvents and a small amount of benzene, extends approximately 750 ft from the southeastern edge of LF17 (Figure 2). The plume boundary is defined by the 5 micrograms per liter (µg/L) total chlorinated VOC contour line. Maximum detected concentrations of groundwater contaminants at LF17, all of which were detected during the 2001-2002 SMU FS groundwater study (USACE, 2005a). Benzene was detected at a maximum concentration

of 17 µg/L. The specific chlorinated solvents found to be of concern in LF17 groundwater are perchloroethene (PCE, also known as tetrachloroethene), trichloroethene (TCE), and their biodegradation products cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride. The maximum detected concentrations of these contaminants at LF17 are: PCE 840 µg/L, TCE 190 µg/L, cis-1,2-DCE 1,400 µg/L, and vinyl chloride 840 µg/L. The groundwater study conducted for the SMU FS found that certain aquifer conditions (e.g., the presence of biodegradation products, and other indicators such as low dissolved oxygen) are strongly favorable for the natural biodegradation of the solvents at this site.

Arsenic was found in one groundwater sample and contributed to the overall human health risk at this site. However, it was found in only one sample and at a concentration below its MCL.

2.4.6.2 SS07/Area 2

Soil samples collected at Site SS07 during the RI were found to contain primarily petroleum-related contaminants and some pesticides. These contaminants were mainly found in the shallow surface soils and their concentrations decreased with depth, indicating that leaching of these contaminants into groundwater is not a concern at the site. The presence of PAHs at a depth of 4 to 6 ft bgs (and beneath a clean soil cap reported to be several feet thick), may be due to the historical practice of burning landfill garbage.

The Area 2 groundwater plume (defined by the 5 µg/L total chlorinated VOC contour line) begins several hundred feet upgradient to the northeast of Site SS07 and flows approximately 2,800 ft southwest to the Base boundary (Figure 2). The plume consists of petroleum and chlorinated solvent contaminants from several sources. The petroleum contamination is associated with Site OT53, a former fuel storage tank farm northeast of Site SS07. The petroleum contamination from Site OT53 is being addressed per a corrective action plan in accordance with the Delaware Regulations Governing Underground Storage Tank Systems, and is therefore not addressed in this ROD. The chlorinated solvents found to be of concern in SS07/Area 2 groundwater are PCE and TCE, and these contaminants are addressed in this ROD. The maximum concentrations of PCE and TCE in Area 2 groundwater, detected during the 2001-2002 SMU FS groundwater study, are 4,500 and 1,300 µg/L, respectively. As documented in the SMU FS Addendum (USACE, 2005a), the assessment of natural attenuation parameters at Area 2 indicates evidence of natural biodegradation of the chlorinated solvents. However, the rate of degradation appears to be insufficient to prevent migration beyond the Base boundary at levels exceeding MCLs.

Arsenic was found in three groundwater samples and beryllium in two samples (of the 11 wells sampled at SS07/Area 2 during the RI), with all detections at concentrations below the respective MCLs for each metal.

There are some uncertainties associated with the SS07/Area 2 data. The maximum PCE concentration (4,500 µg/L) was found during the 2001-2002 groundwater study in one

shallow groundwater sample collected on the northeast corner of SS07, possibly indicating a localized source area. There is also limited data in the northeastern-most area of the Area 2 plume upgradient of SS07. Additional sampling is recommended to better define these uncertainties as discussed in Section 2.8.1.10.

2.4.6.3 FT01

Contaminants found in soil samples collected at FT01 during the RI were limited to some pesticides and metals. The presence of these contaminants is related to the surface application of pesticides and soil conditioners during golf course maintenance activities, and is not related to historic activities at the fire training area. Additionally, petroleum-impacted soil associated with the buried 55-gallon drums found at the site was excavated at the time the drums were removed in 1998. Thus, soil at this site is not currently affecting groundwater.

Groundwater contamination associated with Site FT01 is limited to a localized area directly downgradient from the former buried drums. The two groundwater contaminants associated with Site FT01 are benzene and chlorobenzene. The maximum detected concentrations of these contaminants are 96 and 170 µg/L, respectively. A small plume, as defined by the 5 µg/L total fuel contaminant contour line, exists at the site (Figure 2). Contaminant concentrations rapidly decline in the downgradient direction and groundwater samples collected 1 foot into the golf course tributary streambed in 1998 revealed no fuel contaminants (USGS, 1999).

2.4.6.4 LF18/Area 9

During the RI, polycyclic aromatic hydrocarbons (PAHs) were found in soil at Site LF18. The presence of PAHs at a depth of 4 to 6 ft bgs (and beneath a clean soil cap reported to be several feet thick), may be due to the historical practice of burning landfill garbage. PAHs can form when organic materials are burned. Evidence of such burning was found during the investigation of LF18. The PAHs detected in LF18 soil and their maximum concentrations are: benzo[a]anthracene at 51,000 µg/kg; benzo[a]pyrene at 34,000 µg/kg; and benzo[b]fluoranthene (or the analytically indistinguishable benzo[k]fluoranthene) at 65,000 µg/kg. Free phase petroleum product was also found at the south corner of Site LF18, which prompted the soil excavation action discussed in Section 2.1.4. Groundwater quality improved significantly after the LF18 soil excavation, indicating that the soil cleanup action was successful and the threat of continued leaching of contaminants from soil to groundwater is minimal (USGS, 1998, 2002; and USACE, 1997, 1999, 2005a).

Surface water and sediment samples collected from the golf course tributary were evaluated during the RI. The golf course tributary is the main surface water drainage channel associated with sites on the golf course, including FT01 and LF18/Area 9.

Groundwater at LF18/Area 9 contained the chlorinated solvents PCE and TCE. The maximum detected concentrations of these contaminants during the RI at LF18/Area 9

are 50 and 150 µg/L, respectively. The chlorinated solvents are confined to the intermediate and deep portions of the Columbia Aquifer in a generally east-west trending plume (Figure 2). The plume is defined by the 5 µg/L total chlorinated VOC contour line. The RI data suggested very old sources in the vicinity of well pair MW032, and the club house near U.S. Route 113 and possibly near the east corner of LF18 next to the Base boundary. However, the most recent data from the 2001-2002 SMU FS groundwater study found only trace detections of chlorinated VOCs in the shallow groundwater (10 to 25 ft bgs), indicating that no obvious source areas remain within the Area 9 plume. There is limited data, and consequently some uncertainty, in the northeastern-most area of the Area 9 plume, where additional sampling is recommended as discussed in Section 2.8.1.10.

One chlorinated VOC, carbon tetrachloride, was present in only three of the 38 wells sampled at LF18/Area 9 during the RI. Carbon tetrachloride was found at higher concentrations during the additional investigation for the SMU FS, with a maximum concentration of 110 µg/L. However, it was present only in samples collected on the opposite side of the golf course tributary from LF18/Area 9. It is attributable to a source in the West Management Unit that is being addressed in the Area 6 ROD, and is therefore not addressed in this ROD.

Three pesticides (alpha-BHC, beta-BHC, and dieldrin) were found in groundwater in up to 10 samples of the 20 groundwater samples collected. Their low-level, ubiquitous presence is more likely related to the application of pesticides at the golf course for over 40 years than to site-related contamination. There are no MCLs for these pesticides.

2.5 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

2.5.1 Land Uses

Current On-Site Land Use. The SMU at DAFB currently has both industrial and residential land use areas. The portion of the SMU northeast of U.S. Route 113 is in the fenced industrial area of the Base. This portion of the SMU can only be entered by passing through the Base's security gates. Sites LF17 and SS07/Area 2 are located within the industrial portion of the SMU, and are not accessible to the general public (Figure 1). This area includes runways and taxiways, maintenance facilities, a fire training area, skeet and small arms firing ranges, and boat/trailer long term parking areas. Southwest across U.S. Route 113, the SMU extends outside of the fenced industrial area and into the Base golf course. Sites FT01 and LF18/Area 9 are located on the golf course, which is adjacent to the Base housing area and bounded to the southwest by the St. Jones River (Figure 1).

Current Adjacent/Surrounding Land Use. Land use in the vicinity of DAFB includes single and multi-family residential areas, industrial zones, commercial land located along major highways, and extensive areas of agricultural and open land. A privately owned sand and gravel quarry is located adjacent and southwest of the SMU, downgradient of the Area 2 groundwater plume (Figure 1).

Reasonably Anticipated Future Land Use. The Base has operated as an airport since 1941. Due to its mission of providing critical air lift capabilities and serving as the joint services port mortuary, the projected land use of DAFB is to remain an active airfield for the foreseeable future. Due to proximity to taxiways and runways, land use at Sites SS07 and LF17 is likely to remain industrial for the foreseeable future. For Sites FT01 and LF18 which are on the Base golf course, land use is likely to remain unchanged for as long as DAFB remains an active airfield.

2.5.2 Surface Water Uses

Current Surface Water Use. There are two main surface water bodies associated with the SMU: the golf course tributary and the St. Jones River (Figure 1). The golf course tributary drains stormwater runoff from the southwest side of the Base, and discharges into the St. Jones River. The golf course tributary is too small to support recreational use, and its only use is as a drainage ditch. The St. Jones River is used for recreational purposes, primarily fishing, but is not used for potable water. The State of Delaware does not classify the St. Jones River as a potable water source.

Potential Beneficial Surface Water Use. The anticipated future use of the St. Jones River is for recreational purposes, as classified by the State of Delaware. It is not expected to be used as a potable water source because the Base and surrounding communities derive their drinking water from groundwater. Consequently, the beneficial use of the St. Jones River is not expected to change from its current recreational use.

2.5.3 Groundwater Uses

Current Groundwater Use. Groundwater from the surficial (Columbia) aquifer is not used at DAFB. DAFB obtains potable water from several supply wells installed either in the Cheswold or Piney Point Aquifers (see Section 2.4.2). However, the State of Delaware considers all aquifers potential sources of drinking water and the Columbia Aquifer is used by the surrounding community. Moreover, the Columbia Aquifer would be considered a Class IIA aquifer, a currently used source of drinking water, based on Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy. Off-Base, the Columbia Aquifer is used predominantly for irrigation and domestic supply. The quarry located adjacent to the SMU does not use the Columbia Aquifer for potable water. However, the quarry has several ponds excavated into the Columbia Aquifer, and moves the water from pond to pond in its industrial processes.

Potential Beneficial Groundwater Use. Groundwater from the Columbia Aquifer on-Base is not expected to be available as a potential drinking water source for at least 50 years due to the presence of groundwater contamination in the SMU and other areas on the Base. Therefore, for the foreseeable future the predicted aquifer uses are not expected to change from their current conditions.

2.6 SUMMARY OF SITE RISKS

This section presents the assessment methods and results for both human health and ecological risk assessments.

2.6.1 Summary of Human Health Risk Assessment

As part of the Basewide RI a Baseline Risk Assessment was conducted. The Baseline Risk Assessment estimates what risks a site poses if no action is taken. It provides the basis for taking action and identifies what contaminants and exposure pathways, if any, need to be addressed by a remedial action. The risk assessment focused on potential pathways by which Base personnel, maintenance and construction workers, and Base residents could be exposed to contaminated materials at the SMU sites, or originating from the sites and migrating downgradient and off-Base. The risk assessment is summarized below.

2.6.1.1 Identification of COCs

Human health risks from exposure to soil, groundwater, surface water, and sediment were assessed in the Basewide RI (USACE, 1997). Contaminants of potential concern (COPCs) were identified using both the historic and the Basewide RI data by comparing the maximum detected concentration of a chemical in each media to its RBSC in accordance with USEPA Region III guidance (USEPA, 1993). Any chemical whose concentration either exceeded its RBSC, or for which no RBSC was available, was identified as a site-related COPC for that medium and was retained for further evaluation during the risk assessment. The RBSCs were developed according to USEPA Region III protocols using standard exposure pathways and available toxicity criteria. The COPCs identified during this initial screening process were then evaluated for human health risks as described in sections 2.6.1.2 through 2.6.1.4. As a result of the Basewide RI risk evaluation, contaminants found to contribute to an elevated human health risk were identified as COCs. Contaminants detected in groundwater at levels exceeding MCLs were also added to the COC list based on either the RI data, the 2001-2002 FS groundwater study, or the USGS study of FT01 discussed in Section 2.4.5.

Table 1 lists the COCs in soil and groundwater for each site, their maximum detected concentrations, and applicable standards for each contaminant (MCLs for groundwater contaminants and risk-based screening criteria (RBSCs) for soil contaminants). Contaminants are listed in Table 1 for one of two reasons, or both: (1) contributing to overall human health risks, indicated by footnote 3, and (2) by exceeding a groundwater MCL. In some instances, contaminants have been determined to not be COC and this is explained for each site in the footnotes to Table 1.

ORIGINAL

Table 1. SMU Site Contamination Summary

GROUNDWATER[1]	Maximum Concentration (µg/L)	MCL (µg/L)
LF17		
Benzene	17	5
cis-1,2-DCE	1,400	70
PCE	840	5
TCE	190	5
Vinyl chloride[3]	840	2
Arsenic[3,4]	6.6	50
SS07/Area 2		
PCE[3]	4,500	5
TCE	1,300	5
Arsenic[3,4]	27.2	50
Beryllium[3,4]	1	4
FT01		
Benzene	96	5
Chlorobenzene	170	100
LF18/Area 9		
Carbon tetrachloride[3,4]	110	5
PCE[3]	50	5
TCE[3]	150	5
Alpha-BHC[3,4]	0.072	--
Beta-BHC[3,4]	0.95	--
Dieldrin[3,4]	0.044	--
SOIL	**Maximum Concentration (µg/kg)**	**RBSC[2] (µg/kg)**
LF18		
Benzo[a]anthracene[3]	51,000	3,900 (980)
Benzo[a]pyrene[3]	34,000	390 (88)
Benzo[b]fluoranthene[3,5]	65,000	3,900 (880)

(1) This table combines data from the Basewide RI, the investigation conducted during the FS, and the USGS study of FT01.

(2) Risk-based screening criterion, commercial/industrial value (residential value).

(3) This contaminant is a partial contributor to human health risks as determined during the Basewide RI.

(4) Although this contaminant contributed to the human health risks, it was eliminated as a COC for the reasons specified in the site discussions in Section 2.4.

(5) The information is the same for benzo[k]fluoranthene, which is analytically indistinguishable from benzo[b]fluoranthene.

Table 2 is the initial list of COCs identified for each site and medium, their detected concentration ranges, detection frequencies, and exposure point concentrations (EPCs) determined during the risk assessment. No COCs were identified in surface water or sediment. The development and use of EPCs in the exposure assessment portion of the risk assessment is discussed in the following section.

ORIGINAL

Table 2. Human Health COC Summary

Groundwater COCs (1)	Concentration Range (µg/L)	Detection Frequency (positive detections/ number of samples)	EPC (µg/L); all values are the 95% UCLs unless noted otherwise
LF17			
Benzene	2	1/11	1.8
cis-1,2-DCE	3–1,400	11/90	-- (2)
PCE	1–840	14/90	-- (2)
TCE	3–140	10/70	-- (2)
Vinyl chloride	11	1/11	3.67
Arsenic	6.6	1/3	6.6 (max)
SS07			
PCE	360-790	2/11	242
TCE	1–1,300	41/107	-- (2)
Beryllium	0.48-1	2/4	0.917
AREA 2			
TCE	1–1,300	41/107	-- (2)
Arsenic	3.2-27.2	2/8	11.3
FT01			
Benzene	0.35–96	7/21	-- (2)
Chlorobenzene	0.21-170	9/21	-- (2)
LF18			
PCE	5	1/22	1.99
TCE	3-150	5/22	27.5
Alpha-BHC	0.012-0.072	2/4	0.0385
Beta-BHC	0.047-0.95	2/4	0.36
AREA 9			
Carbon tetrachloride	1-3	3/38	1.32
TCE	2-150	14/38	21.6
Alpha-BHC	0.00033-0.072	5/20	0.0181
Beta-BHC	0.0033-0.95	4/20	0.141
Dieldrin	0.00027.044	10/20	0.0109
Soil COCs (3)	**Concentration Range (µg/kg)**	**Detection Frequency (positive detections/ number of samples)**	**EPC (µg/kg); all values are the 95% UCLs**
LF18			
Benzo[a]anthracene	73-51,000	3/7	15,600
Benzo[a]pyrene	41-34,000	3/7	9,500
Benzo[b]fluoranthene (4)	100-65,000	3/7	18,400

(1) Groundwater COCs were identified based on the RI human health risk assessment, or based on MCL exceedances detected during any investigation. For COCs identified during the RI risk assessment, EPCs were calculated as listed in the table. COCs later identified based on MCL exceedances, but that were not contributors to risk during the RI risk assessment, do not have EPC values.

(2) This chemical was not identified during the Basewide RI risk assessment as a COC but was added based on post-RI sampling that showed groundwater concentrations above its MCL as indicated in footnote (1).

(3) Soil COCs at LF18 were identified based on residential exposure through ingestion and inhalation of soil by children and adults.

(4) The information is the same for benzo[k]fluoranthene, which is analytically indistinguishable from benzo[b]fluoranthene.

2.6.1.2 Exposure Assessment

The exposure assessment is a process of characterizing the exposure setting, identifying exposure points and pathways (i.e., routes by which COPCs pass from contaminated media to human receptors), and quantifying exposure. The Site Conceptual Model (Section 2.4.1) is used to determine reasonable exposure scenarios and pathways of concern. Routes of exposure are based on the current, future, and, in some cases, hypothetical land and groundwater uses (see Section 2.5).

Identification of Exposure Scenarios. It is assumed that current Base workers can be exposed to residual contaminants in the surface and subsurface soil during regular maintenance activities (e.g., utility installation or repair). Potential risks associated with the current workers' exposure to contaminants in groundwater are not calculated, because groundwater from the Columbia Aquifer is not currently being used anywhere on Base. It is assumed that future on-site workers can be exposed to residual contaminants in soil through construction or excavation activities. A hypothetical future commercial/ industrial groundwater use was also assumed such that: (1) there are commercial/ industrial users located on Base who will use the Columbia Aquifer in the future as a source of water for drinking and showering, and (2) concentrations detected during the Basewide RI on or near the site represent the concentrations to which these users may be exposed (USACE, 1997). Two sites are located at the Base golf course (FT01 and LF18/Area 9). For these sites, residential exposures were also assessed. Finally, recreational exposure to surface water and sediment in the golf course tributary was assessed. The receptors and exposure pathways considered for all media at the SMU sites are:

- Current and future commercial/industrial exposure to an on-Base worker through inhalation and ingestion of soil during construction or excavation.

- Hypothetical future commercial/industrial exposure to an on-Base worker through inhalation and ingestion of groundwater (on Base).

- Residential exposure at sites located at the Base golf course (FT01 and LF18/Area 9) through ingestion and inhalation of soil and groundwater by children and adults.

- Recreational exposure through ingestion of surface water and sediment from the golf course tributary by a person who accidentally falls into the stream. (The stream is too small for swimming or sport/sustenance fishing.)

Quantification of Exposure Point Concentrations (EPCs). EPCs are calculated by estimating the 95 percent upper confidence limit (UCL) on the arithmetic mean concentration for each COPC. Where the calculated EPC exceeds the COPC's maximum concentration, the maximum concentration is used as the EPC in the risk assessment. The EPCs for each COC identified in the risk assessment were previously shown in

Table 2. For those COCs later identified based on MCL exceedances (but that were not contributors to risk during the RI risk assessment), no EPCs were calculated.

2.6.1.3 Toxicity Assessment

The objective of the toxicity assessment is to evaluate available information regarding the potential for COPCs to cause adverse health effects in exposed individuals, and to provide the analytical framework for the characterization of human health impacts. The toxicity assessment summarizes published data on human health effects. This includes quantitative reference doses (RfDs) for noncarcinogenic effects (health problems other than cancer) and slope factors (SFs) for carcinogenic effects (cancer). RfDs represent the maximum acceptable uptake of noncarcinogens by humans, expressed in milligrams of chemical per kilogram of body weight per day. SFs are quantitative estimates of the increased probability of cancer developing in an exposed individual. SFs are expressed as the lifetime cancer risk per milligram of chemical per kilogram of body weight per day. A summary of the toxicity data for SMU COCs is included in Table 3.

2.6.1.4 Risk Characterization

The final step of the baseline risk assessment, risk characterization, consists of quantitative estimates of carcinogenic risk and noncarcinogenic hazard, which are derived by relating estimated intakes to toxicity criteria. Carcinogenic risks and noncarcinogenic hazards are quantified for each contaminant. The terms "lifetime excess cancer risk" (LECR) and "hazard index" (HI) are used to refer to carcinogenic and noncarcinogenic health effects, respectively.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$LECR = CDI \times SF$$

where:

LECR = a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as $(mg/kg\text{-}day)^{-1}$

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as

Table 3. Cancer and Non-Cancer Toxicity Data Summary

	Cancer Toxicity Data				Non-Cancer Toxicity Data			
COC	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Dermal Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight of Evidence/Cancer Guideline Description	Source (1)	Oral Reference Dose (mg/kg-day)	Dermal Reference Dose (mg/kg-day)	Primary Target Organs/Uncertainty Factor (UF)	Source (1)
Soil								
Pathway: Ingestion								
Benzo[a]anthracene	0.73	*	B2	USEPA		*		
Benzo[a]pyrene	7.3	*	B2	IRIS		*		
Benzo[b]fluoranthene	0.73	*	B2	USEPA		*		
Pathway: Inhalation								
Benzo[a]anthracene	0.61	*	B2	USEPA		*		
Benzo[a]pyrene	6.1	*	B2	HEAST		*		
Benzo[b]fluoranthene	0.61	*	B2	USEPA		*		
Groundwater								
Pathway: Ingestion								
Carbon tetrachloride	0.13	*	B2	IRIS	7×10^{-4}	*	Liver; UF = 1000	IRIS
PCE	0.05	*	B2	HEAST	1×10^{-2}	*	Hepatotoxicity; UF = 1000	IRIS
TCE	0.01	*	B2	HEAST	6×10^{-3}	*	Hepatotoxicity	USEPA
Vinyl chloride	1.90	*	A	HEAST		*		
Alpha-BHC	6.2	*	B2	IRIS		*		
Beta-BHC	1.8	*	C	IRIS		*		
Dieldrin	16.0	*	B2	IRIS	5×10^{-5}	*	Liver; UF = 100	HEAST
Arsenic	1.75	*	A	IRIS	3×10^{-4}	*	skin, vascular complications, UF = 3	IRIS
Beryllium	4.3	*	B2	IRIS	5×10^{-3}	*	No adverse effects; UF = 100	IRIS
Pathway: Inhalation								
Carbon tetrachloride	0.053	*	B2	HEAST	5.71×10^{-4}	*	No data	USEPA
PCE	0.001	*	B2	USEPA		*		

Table 3. Cancer and Non-Cancer Toxicity Data Summary (continued)

	Cancer Toxicity Data				Non-Cancer Toxicity Data			
COC	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Dermal Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight of Evidence/Cancer Guideline Description	Source (1)	Oral Reference Dose (mg/kg-day)	Dermal Reference Dose (mg/kg-day)	Primary Target Organs/Uncertainty Factor (UF)	Source (1)
TCE	0.006	*	B2	USEPA		*		
Vinyl chloride	0.3	*	A	HEAST		*		
Alpha-BHC	6.3	*	B2	IRIS		*		
Beta-BHC	1.8	*	C	IRIS		*		
Dieldrin	16.1	*	B2	IRIS		*		
Arsenic	15.1	*	A	IRIS		*		
Beryllium	8.4	*	B2	IRIS		*		

*Dermal exposure was not evaluated.

Empty portions of the table reflect that this data was not available at the time of the Basewide RI risk assessment.

UF = uncertainty factor, listed where available. The higher this value, the greater the uncertainty in the estimation of toxic effects on human health.

(1) Source:

IRIS, Integrated Risk Information Management System, 1995

HEAST, Health Effects Assessment Summary Tables, 1994

USEPA, U.S. Environmental Protection Agency, Risk-Based Concentration Tables, 1994

Cancer Guideline Description:

A - Human carcinogen

B1 - Probable human carcinogen, limited human data available

B2 - Probable human carcinogen, sufficient data for animals, insufficient data for humans

C - Possible human concinogen, limited data for animals

D - Not classifiable as a human carcinogen

one in three. According to EPA guidance, the generally acceptable LECR range for site-related exposures is 1×10^{-4} to 10^{-6}. The risk characterization for carcinogens at the SMU sites is summarized in Table 4.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a RfD derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all COCs that affect the same target organ (e.g., liver) or that have some other critical effect such as reproductive toxicity. An HI<1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI>1 indicates that site-related exposures may present a risk to human health. The HQ is calculated as follows:

$$HQ = CDI/RfD$$

where: CDI = chronic daily intake
RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e. chronic, subchronic, or short-term). The risk characterization for non-carcinogens at the SMU sites is summarized in Table 4.

To evaluate the total risk for the site, the LECR and HI values are summed for all contaminants for each pathway. The numerical results are compared to USEPA comparison criteria to determine if risks are present that warrant action. The USEPA comparison criteria are 1×10^{-4} for the LECR and 1 for the HI. USEPA guidance states that "where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 1×10^{-4}, and the noncarcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts" (USEPA, 1991). However, in general, exceeding MCLs in groundwater that is an actual or potential designated drinking water source justifies action under CERCLA and the NCP.

Table 5 summarizes the carcinogenic and non-carcinogenic human health risk values for each exposure pathway at the SMU sites. As shown in the table, the total HI values for all exposure scenarios are less than the HI comparison criterion of 1. Thus, under the exposure scenarios selected, there are no unacceptable non-carcinogenic health risks for any media (surface water, sediment, soil, groundwater) at any of the SMU sites. The total LECR values for all exposure scenarios are less than the LECR comparison criterion of 1×10^{-4} except for the residential exposure to soil at LF18. In accordance with USEPA Superfund guidance, from a human health perspective and under the exposure

Table 4. Risk Characterization Summary Highlights

LF17 Groundwater, Ingestion & Inhalation
Future Hypothetical Commercial/Industrial

	Carcinogenic Risk			Non-Carcinogenic Hazard			
COC	Ingestion	Inhalation	Total	Ingestion	Inhalation	Primary Target Organ	Total
Vinyl chloride	2×10^{-5}	5×10^{-6}	3×10^{-5}				
Arsenic	4×10^{-5}		4×10^{-5}	0.2		skin, vascular	0.2
LF17 groundwater risk total[(1)] =			8×10^{-5}	LF17 groundwater hazard total =			<1

SS07 Groundwater, Ingestion & Inhalation
Future Hypothetical Commercial/Industrial

	Carcinogenic Risk			Non-Carcinogenic Hazard			
COC	Ingestion	Inhalation	Total	Ingestion	Inhalation	Primary Target Organ	Total
PCE	4×10^{-5}	2×10^{-6}	4×10^{-5}	0.2		liver	0.2
Beryllium	1×10^{-5}		1×10^{-5}	0.002			0.002
SS07 groundwater risk total[(1)] =			6×10^{-5}	SS07 groundwater hazard total =			<1

Area 2 Groundwater, Ingestion & Inhalation
Future Hypothetical Commercial/Industrial

	Carcinogenic Risk			Non-Carcinogenic Hazard			
COC	Ingestion	Inhalation	Total	Ingestion	Inhalation	Primary Target Organ	Total
Arsenic	7×10^{-5}		7×10^{-5}	0.4		skin, vascular	0.4
Area 2 groundwater risk total =			7×10^{-5}	Area 2 groundwater hazard total =			<1

FT01 Soil, Ingestion & Inhalation
Residential & Current & Future Commercial/Industrial
FT01 Groundwater, Ingestion & Inhalation
Future Hypothetical Residential & Commercial/Industrial

No risks above USEPA or DNREC criteria were determined to be present at FT01 under these scenarios.

Table 4. Risk Characterization Summary Highlights (continued)

LF18 Soil, Ingestion & Inhalation
Residential (adult)*

	Carcinogenic Risk			Non-Carcinogenic Hazard			
COC	Ingestion	Inhalation	Total	Ingestion	Inhalation	Primary Target Organ	Total
Benzo[a]anthracene	2×10^{-5}	3×10^{-10}	2×10^{-5}				
Benzo[a]pyrene	1×10^{-4}	2×10^{-9}	1×10^{-4}				
Benzo[b]fluoranthene	2×10^{-5}	4×10^{-10}	2×10^{-5}				
LF18 soil risk (adult) total[(1)] =			2×10^{-4}	LF18 soil hazard (adult) total =			<1

*Hazard for child exposure was below 1 and cancer risk is only evaluated for the adult, which accounts for the time spent as a child.

LF18 Soil, Ingestion & Inhalation
Current & Future Commercial/Industrial

No risks above USEPA or DNREC criteria were determined to be present at LF18 under this scenario.

LF18 Groundwater, Ingestion & Inhalation
Residential (adult)*

	Carcinogenic Risk			Non-Carcinogenic Hazard			
COC	Ingestion	Inhalation	Total	Ingestion	Inhalation	Primary Target Organ	Total
PCE	2×10^{-6}	5×10^{-8}	2×10^{-6}	0.003		liver	0.003
TCE	5×10^{-6}	2×10^{-6}	7×10^{-6}	0.02		liver	0.02
Alpha-BHC	4×10^{-6}	2×10^{-7}	4×10^{-6}				
Beta-BHC	1×10^{-5}	5×10^{-7}	1×10^{-5}				
LF18 groundwater risk (adult) total[(1)] =			4×10^{-5}	LF18 groundwater hazard (adult) total =			<1

*Hazard for child exposure was below 1 and cancer risk is only evaluated for the adult, which accounts for the time spent as a child.

LF18 Groundwater, Ingestion & Inhalation
Future Hypothetical Commercial/Industrial

No risks above USEPA or DNREC criteria were determined to be present at LF18 under this scenario.

Table 4. Risk Characterization Summary Highlights (continued)

Area 9 Soil, Ingestion & Inhalation
Residential & Current & Future Commercial/Industrial

No risks above USEPA or DNREC criteria were determined to be present at Area 9 under these scenarios.

Area 9 Groundwater, Ingestion & Inhalation
Residential (adult)*

	Carcinogenic Risk			Non-Carcinogenic Hazard			
COC	Ingestion	Inhalation	Total	Ingestion	Inhalation	Primary Target Organ	Total
Carbon tetrachloride	3×10^{-6}	8×10^{-7}	4×10^{-6}	0.07	0.06	liver	0.1
TCE	4×10^{-6}	1×10^{-6}	5×10^{-6}	0.1		liver	0.1
Alpha-BHC	2×10^{-6}	2×10^{-8}	2×10^{-6}				
Beta-BHC	4×10^{-6}	2×10^{-9}	4×10^{-6}				
Dieldrin	3×10^{-6}	3×10^{-7}	3×10^{-6}	0.003		liver	0.003
Area 9 groundwater risk (adult) total[(1)] =			2×10^{-5}	Area 9 groundwater hazard (adult) total =			<1

*Hazard for child exposure was below 1 and cancer risk is only evaluated for the adult, which accounts for the time spent as a child.

Golf Course Tributary, Surface Water & Sediment, Ingestion
Recreational

No risks above USEPA or DNREC criteria were determined to be present at at the Golf Course Tributary under this scenari

NOTES:

[(1)]Total risks and hazard values are the sum of all COPCs that were retained from the initial screening and for which toxicity data were available. This table lists only those contaminants that contributed significantly to the total. Thus, the total may not precisely match the sum of the COCs due to the omission of low level COPCs and to rounding the total to one significant figure. Additionally, although listed here, some contaminants are not COCs. The various reasons for this are discussed in the text for each site.

Table 5. Risk Characterization Comprehensive Summary

Site/Receptor	Soil Ingestion	Soil Inhalation	Groundwater Ingestion	Groundwater Inhalation	Surface Water Ingestion	Sediment Ingestion	Total (1)
LF17 - HI							
on-site worker, current	NQR	NQR	--	--	--	--	NQR
on-site worker, future	NQR	NQR	0.2	0.01	--	--	0.2
LF17 - LECR							
on-site worker, current	6×10^{-8}	2×10^{-12}	--	--	--	--	6×10^{-8}
on-site worker, future	1×10^{-6}	9×10^{-11}	7×10^{-5}	6×10^{-6}	--	--	8×10^{-5}
SS07 - HI							
on-site worker, current	0.001	NQR	--	--	--	--	0.001
on-site worker, future	0.3	NQR	0.3	0.007	--	--	0.6
SS07 - LECR							
on-site worker, current	3×10^{-7}	1×10^{-10}	--	--	--	--	3×10^{-7}
on-site worker, future	5×10^{-6}	1×10^{-8}	6×10^{-5}	3×10^{-6}	--	--	7×10^{-5}
Area 2 - HI							
on-site worker, current	NQR	NQR	--	--	--	--	NQR
on-site worker, future	NQR	NQR	0.4	0.004	--	--	0.4
Area 2 - LECR							
on-site worker, current	NQR	NQR	--	--	--	--	NQR
on-site worker, future	NQR	NQR	7×10^{-5}	2×10^{-6}	--	--	7×10^{-5}
FT01 - HI							
on-site worker, current	NQR	NQR	--	--	--	--	NQR
on-site worker, future	NQR	NQR	0.03	0.03	--	--	0.06
adult resident	0.003	NQR	0.1	0.08	--	--	0.2
child resident	0.009	NQR	0.3	0.2	--	--	0.5
FT01 - LECR							
on-site worker, current	NQR	NQR	--	--	--	--	NQR
on-site worker, future	NQR	NQR	1×10^{-6}	6×10^{-7}	--	--	2×10^{-6}
adult resident	9×10^{-7}	2×10^{-11}	7×10^{-6}	2×10^{-6}	--	--	1×10^{-5}
child resident	--	--	--	--	--	--	--

Table 5: Risk Characterization Comprehensive Summary (continued)

Site/Receptor	Soil Ingestion	Soil Inhalation	Groundwater Ingestion	Groundwater Inhalation	Surface Water Ingestion	Sediment Ingestion	Total (1)
LF18 - HI							
on-site worker, current	NQR	NQR	--	--	--	--	NQR
on-site worker, future	NQR	NQR	0.08	0.05	--	--	0.1
adult resident	0.006	NQR	0.3	0.1	--	--	0.4
child resident	0.02	NQR	0.5	0.3	--	--	0.8
LF18 - LECR							
on-site worker, current	8×10^{-7}	5×10^{-11}	--	--	--	--	8×10^{-7}
on-site worker, future	1×10^{-5}	3×10^{-9}	6×10^{-6}	1×10^{-6}	--	--	2×10^{-5}
adult resident	2×10^{-4}	3×10^{-9}	3×10^{-5}	5×10^{-6}	--	--	2×10^{-4}
child resident	--	--	--	--	--	--	--
Area 9 - HI							
on-site worker, current	0.00006	NQR	--	--	--	--	NQR
on-site worker, future	0.02	NQR	0.06	0.04	--	--	0.1
adult resident	0.04	0.000002	0.2	0.1	--	--	0.3
child resident	0.1	0.000004	0.4	0.2	--	--	0.7
Area 9 - LECR							
on-site worker, current	2×10^{-8}	2×10^{-12}	--	--	--	--	2×10^{-8}
on-site worker, future	3×10^{-7}	1×10^{-10}	4×10^{-6}	1×10^{-6}	--	--	5×10^{-6}
adult resident	7×10^{-6}	1×10^{-10}	2×10^{-5}	4×10^{-6}	--	--	3×10^{-5}
child resident	--	--	--	--	--	--	--
Golf Course Tributary - HI							
recreational user	--	--	--	--	0.01	0.006	0.02
Golf Course Tributary - LECR							
recreational user	--	--	--	--	1×10^{-6}	9×10^{-7}	2×10^{-6}

(1) Summation of values for all media
NQR - No quantifiable risk
-- Not a valid receptor/pathway

scenarios selected for each site, there are no unacceptable carcinogenic health risks for any media at any of the SMU sites with the exception of soil at LF18.

Although groundwater risks under the exposure scenarios selected for each site are below the USEPA comparison criteria, groundwater contaminant concentrations in the Columbia Aquifer at all four SMU sites exceed federal MCLs (Table 1). Even though the Columbia Aquifer is not used at Dover AFB, it is used as a drinking water source in areas surrounding Dover AFB. Therefore, based on these MCL exceedances, action is warranted to address groundwater contamination at LF17, SS07/Area 2, FT01, and LF18/Area 9. Action is also warranted to address risk from soil contamination at LF18.

The results of the risk calculations contain an inherent level of uncertainty due to the various assumptions made and gaps in our knowledge on the particular health effects of some chemicals. The major sources of uncertainty and whether these are expected to under- or overestimate the potential risk are highlighted here:

- All sampling programs can only partially characterize a site. Although extensive data have been collected at the SMU sites, it is possible that some contamination has been missed. This may cause the risk to be underestimated.

- Toxicity data for some of the contaminants may not exist. Thus, these contaminants are not considered in the final risk values, which would be underestimated.

- For estimates of future risk, the contaminant concentrations were assumed to be the same as current levels. Over time, it is more likely that there would be some degradation or attenuation of contaminants. Thus, the future risks are overestimated.

- Dermal exposures were not estimated for any media. Excluding this pathway may have underestimated the cancer risks and non-cancer hazards.

- Vapor intrusion from sub-surface contamination into buildings was not assessed during the baseline risk assessment. Excluding this pathway may have underestimated risk.

- Since the risk assessment was conducted in 1993-1994, some of the toxicity factors (shown in Table 3) have changed. In general, the values have become more restrictive, indicating that the originally calculated risks and hazards are likely underestimated. Thus, there is some potential for EPA comparison criteria to be exceeded at sites currently below those levels.

The final list of COCs that warrant action was determined by taking several factors into consideration: site risks, exceedance of groundwater MCLs, the nature and extent of contamination at each site, and, lastly, the potential breakdown products of the primary COCs if such breakdown products were not already identified at the site. Considering

these factors, one VOC (carbon tetrachloride), two metals (arsenic and beryllium), and three pesticides (alpha-BHC, beta-BHC, and dieldrin) were eliminated as COCs. Carbon tetrachloride and the two metals were only detected sporadically at low concentrations with none of the detections exceeding federal MCLs. The low level detections and ubiquitous presence of the three pesticides are likely related to the application of pesticides at the golf course for over 40 years, and are not site-related. Conversely, two chemicals (cis-1,2-DCE and vinyl chloride) were added as COCs for Sites SS07/Area 2 and LF18/Area 9. These are expected breakdown products of the primary COCs PCE and TCE at these sites. Although these two breakdown contaminants were not identified as COCs during the field investigations or risk assessment, they are added to the final COC list here because they are likely to be observed during monitoring of the remedial actions. Based on these factors, the final list of COCs requiring action at each site are:

GROUNDWATER

LF17: benzene, cis-1,2-DCE, PCE, TCE, vinyl chloride

SS07/Area 2: PCE, TCE, cis-1,2-DCE, vinyl chloride

FT01: benzene, chlorobenzene

LF18/Area 9: PCE, TCE, cis-1,2-DCE, vinyl chloride.

SOIL

LF18/Area 9: benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene

During their review, an updated human health risk evaluation was performed by the USEPA. USEPA may differ with the Air Force on the exact HIs and cancer risks involved, due to differences in exposure and toxicity factors, but was able to confirm the overall conclusions that risk for workers exposed to soil, sediment, and surface water from the various sites would be acceptable. Construction or industrial workers exposed to groundwater at Sites SS07, LF18, Area 2, and Area 9 might be exposed to an unacceptable risk.

For the residential exposure scenario, the USEPA calculated potentially unacceptable cancer risks from the groundwater at all the sites. At Site LF17, the LECR was 2×10^{-4} resulting from potential exposure to vinyl chloride. At Site SS07, the LECR was 2×10^{-3} resulting from potential exposure to PCE, TCE, and vinyl chloride. For Area 2, the LECR was 6×10^{-4} driven mostly by potential TCE exposure. For Site FT01, the LECR was 1×10^{-4} resulting from TCE concentrations detected in the groundwater (these TCE values may be related to groundwater from Area 9). For Site LF18, the LECR was 6.5×10^{-3} and for Area 9, the LECR was 1×10^{-3} both resulting from potential exposure to TCE. Additionally, the EPA confirmed the potential cancer risk from potential exposure

to soils at Site LF18 (LECR 3 x 10^{-4}) from benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and benzo[a,h]anthracene.

For the residential exposure scenario, the EPA calculated potentially unacceptable non-cancer risks from the groundwater at each site. At LF17, HI = 33, based on detections of iron, manganese, and nitrite. For Site SS07, HI = 16, based on PCE, TCE, and acetone detections. For Area 2, HI = 19, mainly from TCE, iron, manganese, and arsenic. For Site FT01, HI = 2.3, resulting mainly from TCE concentrations detected in the groundwater (these TCE values may be related to groundwater from Area 9) and nitrite. For Area 9, HI = 27, resulting from TCE, iron, and manganese. Elevated concentrations of iron, manganese, nitrite, and even arsenic may be the result of the reducing conditions in the groundwater related to natural attenuation of the solvent plumes; therefore, the risk from these chemicals should be re-evaluated at the end of any long-term monitoring and completion of any natural attenuation. The EPA calculated the potential for non-cancer risks from soils at several sites, but based on a risk management decision that the chemicals were found at or near the background concentration, these potential risks were overestimated.

2.6.2 Summary of Ecological Risk Assessment

A Basewide ERA was performed as part of the RI and documented in a separate ERA report (USACE, 2000). This assessment is different from the human health risk assessment since it used a Base-wide rather than a site-by-site approach in the evaluation of potential risks. The Basewide approach allows assessment of the cumulative effects of multiple sites on the Base ecology and more reasonably accounts for such factors as foraging range. This assessment, like that for human health, is a complex, multi-step process of comparing data to various benchmarks, and then calculating numerical estimates of risk.

All RI surface water, sediment, surface soil, and groundwater analytical data from all sites were compiled and compared to benchmarks in a tiered approach to evaluate the potential risk. The ERA procedures (a three-tiered process) are outlined below.

2.6.2.1 Tier I: Problem Formulation/Scoping Assessment

The scoping assessment includes 1) characterization of the nature and quality of the habitat and ecological resources on and around the Base; 2) identification of COPCs and receptors of concern (ROCs), and 3) identification of potentially complete exposure pathways. Non-chemical stressors are also identified. The scoping assessment concludes with the elimination of COPCs that do not come in contact with, and thus, cannot cause risk to ROCs.

2.6.2.2 Tier II: Analysis

The objective of this phase of analysis is to focus on those COPCs that are most likely to cause adverse effects (e.g., reproduction problems) in the ROCs. The analysis uses a

multi-stage process that compares the list of COPCs developed in Tier I above (i.e., those that have potentially complete exposure pathways) to toxicity screening values (TSVs) using increasingly more realistic assumptions. The benchmarks against which site conditions are initially compared are standard soil quality guideline values. Where these are not available, they are developed using the available scientific literature.

2.6.2.3 Tier III: Risk Characterization

For several reasons, COPC concentrations exceeding screening benchmarks may not, in fact, present unacceptable ecological risks. For example, an organism may only be present for short periods in an elevated risk area, which may over-value its significance. If risk is predicted under conservative default assumptions such as 100 percent bioavailability or 100 percent area use factors, more appropriate assumptions are made in an iterative fashion until a more ecologically realistic exposure scenario is produced. This first phase is the Screening Level ERA (SLERA). The SLERA concludes with decisions about the locations and degrees of risk to generic ROCs under reasonable worst-case exposure scenarios. The concentrations used in this part of the assessment are the maximum detected values or the 95 percent UCLs.

The baseline ERA is performed next and synthesizes both toxicological data as well as the ecological data for the site-specific ROCs. Site-specific ROCs such as the kingfisher or shrew were selected based on several factors including how well the ROC represents a specific habitat and its exposure sensitivity. Biomagnification factors are also taken into account. It may require more than one iteration, depending on the complexity of the site. Carefully identified site and scientific information from peer-reviewed literature are used to reduce uncertainties associated with the conservative assumptions about toxicity and exposure used in the SLERA. Additional iterations are used to reduce uncertainty in the variables used in the evaluation.

The concentrations used in this stage of the assessment may be derived from statistical UCLs, means, or medians, depending on the species-specific foraging habits. If the estimated concentrations are below species-specific toxicity benchmarks (toxicity reference values [TRVs]), then associated COPC-pathway combinations are concluded to present no unacceptable ecological risk. They are then dropped from further consideration. Any contaminants remaining at this stage are ecological COCs.

2.6.2.4 ERA Results

Surface Water. No unacceptable risk to native fish was assessed for any of the COPCs in surface waters at DAFB. This prediction was validated in bioassay studies that were conducted in the Fall of 1991 on organisms collected at DAFB.

No risk of adverse reproductive effects was assessed for the belted kingfisher (a North American bird) from any of the COPCs that may biomagnify through food chains. This prediction was partially validated as no pesticides or PCBs were found in fish collected

from Pipe Elm Branch, Morgan Branch, or the St. Jones River tributary that runs through the DAFB golf course. Since the kingfisher has a higher exposure rate than the raccoon, mallard or muskrat, and reproductive endpoints were used to establish TRVs for these species, there is no risk of reproductive ill effects in any of these potential ROCs.

The ERA concluded that no action is necessary to address ecological risks for the surface water medium at DAFB because no risk was found for any ROC exposed to any surface water COPC.

Sediment. A low degree of risk was found for benthic invertebrates (e.g., worms) exposed to the 95 percent UCL for sediment zinc concentrations. The highest risk was found in the upstream portion of the North Drainage Ditch (ERP Site SD12), which discharges to Pipe Elm Branch. However, no risk was found for benthic invertebrates exposed to the mean zinc concentration, even within Pipe Elm Branch, because the highest zinc concentrations were detected within a small, localized area at the end of a drainage pipe in the SD12 area. No risk to benthic invertebrates was found for any other COPC in sediment. This conclusion was validated in bioassay studies conducted in 1991.

A low risk of adverse reproductive effects was found for snipe (a bird common to marshes) exposed to the 95 percent UCL for sediment DDD, DDE, and DDT concentrations. The highest concentrations of DDD, DDE, and DDT were found near a portion of Pipe Elm Branch in the East Management Unit. However, even in this area, no unacceptable risk was found for snipes exposed to the mean DDD, DDE, and DDT concentrations. Since the snipe has a higher exposure rate than raccoon, mallard, or muskrat, and reproductive endpoints were used to establish TRVs for these species, there is no risk of reproductive ill effects in these potential ROCs.

The ERA concluded that zinc, DDT, DDD, and DDE in sediment pose some minor, localized risks to the environment. However, ecological risks over an entire drainage area are minimal. The localized risks at Site SD12 and the Pipe Elm Branch are being addressed in the Proposed Plan and ROD for Site SD12.

Soil. COPCs in soil posed no risk to any ROC, and, therefore, the ERA concluded that no action is necessary to address ecological risks from soil at DAFB.

Groundwater. Ecological risks were assessed for groundwater as it discharges to surface streams or flows towards the Base boundaries. No unacceptable risks to ROCs were found, thus no further action is necessary to address ecological risks from groundwater at DAFB.

2.6.3 Basis for Action

The human health risk assessment for the SMU sites concluded that:

- Carcinogenic risk from residential exposure to soil at LF18 exceeds the USEPA risk criteria.

- Groundwater contaminant concentrations in the Columbia Aquifer at LF17, SS07/Area 2, FT01, and LF18/Area 9 exceed federal MCLs; the Columbia Aquifer is a currently used source of drinking water.

Additionally, the risk assessments for Sites LF17 and SS07 were based on assumptions that land use at these sites will remain industrial. Therefore, action is warranted to address soil risk at LF18, MCL exceedances in groundwater at all four of the SMU sites, and to ensure the permanence and reliability of the land use assumptions used to assess these sites. It is the USAF's current judgment that the response action selected in this ROD is necessary to protect the public health or welfare from actual releases of hazardous substances into the environment at LF17, SS07/Area 2, FT01, and LF18/Area 9.

2.7 REMEDIAL ACTION OBJECTIVES (RAOs)

RAOs are medium-specific goals that the selected remedial alternative must achieve to protect human health and the environment. The development of RAOs for the sites in this ROD was documented in the FS for the SMU (USACE, 2005a) based on the results of the human health risk assessment. The RAOs developed for soil and groundwater contamination at the four SMU sites are as follows:

(a) Reduce concentrations of the specified contaminants identified in the Columbia Aquifer near these sites to the levels shown in Table 6. These quantitative RAOs (also called Preliminary Remediation Goals) are based on the federal drinking water MCLs as listed in EPA 816-F-03-016, June 2003, and established under the Safe Drinking Water Act.

(b) Prevent exposure to groundwater from the Columbia Aquifer near these sites until such time as cleanup levels (shown in Table 6) for the contaminants in the aquifer have been obtained and risks from groundwater use are shown to be reduced to levels that allow for unrestricted exposure and unlimited use.

Table 6. Quantitative Groundwater RAOs

Contaminant	LF17	SS07/Area 2	FT01	LF18/Area 9	RAO* (µg/L)
Benzene	X		X		5
Chlorobenzene			X		100
cis-1,2-DCE	X	•		•	70
PCE	X	X		X	5
TCE	X	X		X	5
Vinyl chloride	X	•		•	2

X - COC present at this site.
• - Potential COC due to the breakdown of other COCs.
*RAO is the federal MCL (EPA 816-F-03-016, June 2003).

LUC Objectives: The Air Force has identified the following LUC performance objectives:

(a) Prevent residential exposures to soil at LF18 until concentrations of hazardous substances at the site are at levels allowing for unrestricted exposure and unlimited use.
(b) Restrict land use at Sites LF17 and SS07/Area 2 to industrial uses, with on-site daycare centers and recreation areas prohibited, until concentrations of hazardous substances at the sites are at levels allowing for unrestricted exposure and unlimited use.
(c) Prohibit digging and other ground-disturbing activities at LF17, SS07/Area 2, LF18, and FT01 that are inconsistent with the objectives listed above. A more complete discussion of the review process is provided in Section 2.8.1.9.
(d) Maintain the integrity of any current and future remedial or monitoring system at these sites.

2.8 DESCRIPTION OF ALTERNATIVES

The remedial action alternatives selection process evaluates and compares remedial alternatives. Remedial action technologies are identified and screened for possible use using the following process:

- Identify ARARs for the sites. ARARs for the SMU sites are tabulated in Attachment 2.

- Develop RAOs for the COCs in all affected media (Section 2.7).

- Identify general response actions for each environmental medium requiring remediation to satisfy the RAOs.

- Identify site-specific remedial technologies that are potentially applicable to each general response action, followed by screening of these technologies based on the criteria of implementability, effectiveness, and cost. The objective is to identify those technologies best suited for further consideration in developing remedial alternatives for the sites/areas. Technologies found to be inapplicable on the basis of waste characteristics and site conditions or incapable of meeting the RAOs are eliminated from further consideration. The remaining candidate technologies that pass the screening process are combined into remedial action alternatives. The alternatives for the SMU are described below.

2.8.1 Description of Remedy Components

The Air Force evaluated eight potential remedial alternatives to address soil and groundwater risks at Sites LF17, SS07/Area 2, FT01, and LF18/Area 9. These eight alternatives are:

- A1 – No Action
- A2 – Natural Attenuation with Monitoring
- A3 – Groundwater Recirculation Wells (GRWs) with In-Well Stripping
- A4 – Permeable Reactive Barriers (PRBs)
- A5 – Groundwater Extraction and Air Stripping (also known as Pump and Treat)
- A6 – *In Situ* Chemical Oxidation
- A7 – Injection/Diffusion Accelerated Biodegradation (AB)
- A8 – AB and Natural Attenuation with Monitoring

The primary components of these remedies are discussed below. The alternatives are numbered to correspond with the numbering of alternatives presented in the FS and Proposed Plan for the SMU (USACE, 2005a,b). LUCs and evaluation of vapor intrusion are common components of each remedial alternative, except the No Action alternative. LUCs are the major component for addressing soil risks at LF18. LUCs are further described in Section 2.8.1.9.

2.8.1.1 A1 – No Action

The no action alternative involves no remedial actions. No efforts would be undertaken to contain, remove, treat, or monitor the contaminant plumes in the SMU. Access to the sites would not be restricted. No LUCs would be undertaken to prevent or minimize the risk of unacceptable exposure to human receptors. Under the No Action alternative, contaminants would continue to degrade, but the effects of such degradation would not be monitored. The No Action alternative is required by Federal regulation to be evaluated so as to provide a reference point for comparing other remedial alternatives.

2.8.1.2 A2 – Natural Attenuation with Monitoring

This alternative relies on naturally occurring biological and physical processes (e.g., biodegradation, dispersion, dilution) to reduce chlorinated solvent and fuel contaminant concentrations in groundwater at all four of the SMU sites. Under this alternative, both source areas and the distal plumes associated with the source areas would be addressed by natural attenuation. Periodic groundwater monitoring would be conducted to evaluate the effectiveness of this process. LUCs would be implemented to control human exposure to contaminants at the sites as described in Section 2.8.1.9. Additional sampling would be performed to better delineate portions of the groundwater plumes as described in Section 2.8.1.10. Operations and maintenance (O&M) requirements for this alternative are minimal, and would primarily involve monitoring well maintenance activities.

An investigation was conducted to evaluate anaerobic biodegradation processes at LF17, SS07/Area 2, and LF18/Area 9 as documented in an addendum to the FS for the SMU (USACE, 2005a). This investigation included the collection of chlorinated VOCs and geochemical indicator data at multiple depth intervals across transects intersecting the plumes. Evidence of anaerobic biodegradation was observed at all of these sites. Trend

analyses show that contaminant concentrations have receded over the last 20 years, and none of the contaminants show increasing concentration trends. Using the USEPA scoring system to assess anaerobic biodegradation, strong evidence exists for anaerobic biodegradation at LF17, while more limited evidence for anaerobic biodegradation exists at SS07/Area 2 and LF18/Area 9. However, even under the more mildly anaerobic/ aerobic conditions present at SS07/Area 2 and LF18/Area 9, biodegradation is occurring albeit at slower rates than would occur under more strongly anaerobic conditions.

For Site FT01, anaerobic biodegradation processes were not assessed because the contaminants of concern at FT01 are aromatic hydrocarbons that degrade under both anaerobic and aerobic conditions. In addition, the extent of the contamination at FT01 is primarily limited to a single well, and contaminant concentrations are relatively low. Fate and transport modeling for FT01 indicates that natural degradation processes will achieve cleanup levels.

2.8.1.3 A3 – Groundwater Recirculation Wells (GRWs) with In-Well Stripping

This alternative includes the *in situ* treatment of groundwater using groundwater recirculation wells installed in defined source areas, or at site boundaries in cases where defined sources do not exist. The process is a type of air sparging that consists of a specially adapted groundwater well that is dual-screened at the base of the well and across the water table. The wells circulate water within the aquifer while injecting air. The air strips organic contaminants from the water which are flushed into the soil above the water table. The contaminants are then recovered and treated using an above-ground vacuum pump and off-gas treatment system (activated carbon). The stripped groundwater is discharged from the well and re-enters the aquifer. O&M requirements for this alternative are in the high range relative to other alternatives, and would include treatment system sampling and analysis, air emissions monitoring, miscellaneous repairs and replacement of worn parts, well maintenance, checking carbon, replacement of carbon canisters, and proper disposal of spent carbon.

This technology would be used to treat the source areas at LF17, SS07/Area 2, and FT01. It would be used as a boundary control strategy at LF18/Area 9 where there are no distinct contaminant source areas, but rather a wide area of low level contamination. The untreated portions of the plumes would be allowed to naturally attenuate. Periodic groundwater monitoring would be conducted to evaluate the effectiveness of this process. LUCs would be implemented to control human exposure to contaminants at the sites as described in Section 2.8.1.9. Additional sampling would be performed to better delineate portions of the groundwater plumes as described in Section 2.8.1.10.

2.8.1.4 A4 – Permeable Reactive Barriers (PRBs)

This alternative involves the emplacement of a reactive material in the path of groundwater flow in order to enhance the degradation of contamination. The technology involves the installation of an impermeable barrier in the aquifer interspersed with permeable sections where the reactive material is emplaced. The impermeable sections

of the barrier funnel the contaminated groundwater through the permeable reactive material. The reactive material (usually zero-valent iron) abiotically degrades chlorinated VOCs. This technology is not effective for fuel contaminants. Operations and maintenance requirements for this technology are minimal and include periodic barrier wall inspections and servicing.

This technology is used as a boundary control and not a source area treatment. It would be applied at the downgradient end of the SS07/Area 2 plume near the Base boundary, and at two locations within the LF18/Area 9 plume to prevent off-Base migration of contaminants. The technology is not suitable for FT01 because it does not treat fuel contamination. It is also not applied to LF17 because of the plume's small size. Contaminants at FT01, LF17 and the untreated portions of SS07/Area 2 and LF18/Area 9 would be allowed to naturally attenuate. Periodic groundwater monitoring would be conducted to evaluate the effectiveness of this alternative. LUCs would be implemented to control human exposure to contaminants at the sites as described in Section 2.8.1.9. Additional sampling would be performed to better delineate portions of the groundwater plumes as described in Section 2.8.1.10.

2.8.1.5 A5 – Groundwater Extraction and Air Stripping (Pump and Treat)

Under this alternative, vertical wells are installed in the aquifer and pumps are installed in the wells to extract contaminated groundwater. The extracted groundwater would be pumped to an above-ground treatment system where it would undergo metals pre-treatment before being sent through an air stripping unit to remove VOCs. The metals pre-treatment is required to remove naturally occurring metals such as iron and manganese which can foul air stripping equipment. The treated groundwater effluent from the air stripper would be tested for VOCs to verify regulatory compliance prior to discharge. O&M activities for this technology are in the high range relative to other alternatives, and include effluent sampling and monitoring, maintenance (clean stripper, check carbon), periodic redevelopment of wells, miscellaneous repairs and replacement of worn parts, replacement of carbon canisters, and proper disposal of spent carbon. This alternative would be applied as a source control strategy at LF17, SS07/Area 2, and FT01 where shallow source areas have been defined. It would be applied as a boundary control strategy at LF18/Area 9 where there are no distinct contaminant source areas, but rather a wide area of low level contamination. For LF17 and SS07/Area 2, treated groundwater would be discharged to a nearby drainage ditch that feeds into a stormwater sewer main, and ultimately discharges to the St. Jones River. For FT01 and LF18/Area 9, treated groundwater would be discharged to the golf course tributary which discharges into the St. Jones River. The portions of the plumes not treated by the groundwater extraction wells would be allowed to naturally attenuate. Periodic groundwater monitoring would be conducted to evaluate the effectiveness of this alternative. LUCs would be implemented to control human exposure to contaminants at the sites as described in Section 2.8.1.9. Additional sampling would be performed to better delineate portions of the groundwater plumes as described in Section 2.8.1.10.

2.8.1.6 A6 – *In Situ* Chemical Oxidation

The *in situ* chemical oxidation process consists of the injection of liquid chemical reagents into the contaminated aquifer, causing oxidizing reactions that convert the contaminants to carbon dioxide and water. Chemical injection would be accomplished through the use of stainless steel wells installed at the application areas. O&M activities for this alternative involve re-injection of chemical reagents after the initial treatment as required to achieve cleanup goals.

This alternative would be used to treat source areas at LF17, SS07/Area 2, and FT01. Chemical oxidation is not considered suitable for application at LF18/Area 9 because there are no remaining source areas; rather, low level contamination exists over a large area at LF18/Area 9. Chemical oxidation is cost prohibitive to apply across large areas, and thus is not considered for LF18/Area 9, which would be allowed to naturally attenuate. Periodic groundwater monitoring would be conducted to evaluate the effectiveness of this alternative. LUCs would be implemented to control human exposure to contaminants at the sites as described in Section 2.8.1.9. Additional sampling would be performed to better delineate portions of the groundwater plumes as described in Section 2.8.1.10.

2.8.1.7 A7 - Injection/Diffusion Accelerated Biodegradation (AB)

AB is an *in situ* innovative technology used to stimulate natural biodegradation processes and remediate chlorinated solvent and hydrocarbon contamination in groundwater. The AB application consists of introducing organic substrates, nutrients, or oxidants into the aquifer to stimulate the growth of native microorganisms, creating an environment where the biodegradation processes occur more rapidly than in the natural system. For sites with chlorinated solvent contamination, introduction of an organic (carbon-containing) substrate and nutrients enhances the anaerobic environment, stimulates the growth of halorespiring anaerobes, and thereby accelerates the rate of reductive chlorination of the contaminants. For sites with hydrocarbon contamination, introduction of oxygen and nutrients stimulates biodegradation by aerobic microbes.

The injection/diffusion method of applying the AB technology uses natural groundwater flow to disperse the injected substrate and nutrient materials into the contaminated aquifer. These materials are injected into the aquifer either through installed groundwater wells or by direct emplacement using a direct push rig or other insertion device. Once injected, the materials flow out into the aquifer via natural advection and dispersion. Multiple or periodic re-injections of the substrate materials may be required depending on the substrate used and the geochemical conditions at the site. O&M activities for this alternative could include redevelopment of wells if needed, but primarily involve multiple re-injections of substrate materials after the initial treatment.

This alternative would be used as a source area treatment at LF17, SS07/Area 2, and FT01. This alternative does not address LF18/Area 9 because there are no remaining source areas; rather, low level contamination exists over a large area at LF18/Area 9

which would be allowed to naturally attenuate. Periodic groundwater monitoring would be conducted to evaluate the effectiveness of this alternative. LUCs would be implemented to control human exposure to contaminants at the sites as described in Section 2.8.1.9. Additional sampling would be performed to better delineate portions of the groundwater plumes as described in Section 2.8.1.10.

2.8.1.8 A8 – AB and Natural Attenuation with Monitoring

This alternative includes a combination of the AB and natural attenuation technologies described in paragraphs 2.8.1.2 and 2.8.1.7. AB would be used to treat the SS07/Area 2 source area. Natural attenuation would apply to LF17, FT01, LF18/Area 9, and the portion of the SS07/Area 2 plume not treated by AB. Periodic groundwater monitoring would be conducted to evaluate the effectiveness of this alternative. LUCs would be implemented to control human exposure to contaminants at the sites as described in Section 2.8.1.9. Additional sampling would be performed to better delineate portions of the groundwater plumes as described in Section 2.8.1.10. O&M activities would primarily involve monitoring well maintenance and re-injection of substrate at SS07/ Area 2.

2.8.1.9 Description of LUCs

LUCs are a common component of each of the remedial alternatives described above except for Alternative A1 – the No Action alternative. LUC provisions as they apply to the SMU sites include the following:

- The Air Force is responsible for and will implement, maintain, monitor, review, report on, and enforce LUCs at Sites LF17, SS07/Area 2, FT01, and LF18/Area 9 in accordance with CERCLA and the NCP to ensure protection of human health and the environment until the concentrations of hazardous substances in the soil and groundwater at these sites are at such levels as to allow for unrestricted exposure and unlimited use.

- Residential land use at LF18 is prohibited, and the turf covering LF18 will be maintained until concentrations of hazardous substances at the site are at levels allowing for unrestricted exposure and unlimited use.

- Land use at LF17 and SS07 is restricted to industrial purposes, with on-site day-care centers and recreation areas prohibited, until concentrations of hazardous substances at the sites are a levels allowing for unrestricted exposure and unlimited use.

- On-site use of groundwater from the Columbia Aquifer is prohibited at LF17, SS07/Area 2, FT01, and LF18/Area 9 until cleanup levels (shown in Section 2.7, Table 6) have been obtained and risks from groundwater use are shown to be reduced to allow for unrestricted exposure and unlimited use.

- Digging and other ground-disturbing activities at LF17, SS07/Area 2, LF18, and FT01 that are inconsistent with the objectives listed above and in Section 2.7, are prohibited. Activities such as utility maintenance and repair that do not alter the current land use do not require USEPA or DNREC prior concurrence but are still subject to LUC administrative processes and procedures described below.

  Specific implementation actions that will be used to effect these land use restrictions and prohibitions are:

  - DAFB has a system for comprehensive land use planning that is currently established by Air Force Instruction (AFI) 32-7062, as further implemented in Air Force Pamphlet 32-1010. The Base General Plan provides pertinent information used in planning and decision-making regarding permissible current and future land uses and activities on DAFB. DAFB will, upon ROD execution, promptly revise the Base General Plan to include all land use restrictions and controls identified by this ROD, to include information and maps related to their location and duration, and listing the 436 CEVR Restoration Program Manager as the point of contact for such restrictions and controls. DAFB shall provide USEPA and DNREC with draft copies of the section of the Base General Plan pertaining to LUCs for review at least 30 days prior to implementation. DAFB shall ensure that these or similar systems and procedures are used for the duration of the remedies specified in this ROD. DAFB shall provide USEPA and DNREC with 30 days notice before initiating any major changes to the Base General Plan that relate to these site restrictions and controls.

  - The Air Force has administrative processes and procedures that require approval for all projects involving construction or digging/subsurface soil disturbance, currently set forth in AFI 32-1001, Operations Management, and AFI 32-1021, Planning and Programming of Facility Construction Projects (also known as the base digging permit process). These instructions require coordination and approval by Base environmental personnel for projects located in or near ERP sites, including sites that have LUCs. DAFB will ensure these or similar processes and procedures remain in place and are complied with for all proposed construction, digging and subsurface soil disturbing activities at LF17, SS07/Area 2, FT01, and LF18/Area 9. DAFB shall provide USEPA and DNREC with 30 days notice before initiating any changes to the "digging permit process" as it relates to these site restrictions and controls.

  - DAFB will submit to the Kent County recording authority, USEPA Region III, and DNREC, survey plats indicating the location and dimensions of landfill Sites LF17 and LF18. These plats will be prepared and certified by a professional land surveyor. The plats will contain a prominently displayed note stating DAFB's obligations to restrict uses and activities at these sites.

The filing of these plats is for notification purposes only, and is not intended, nor can it create a property right.

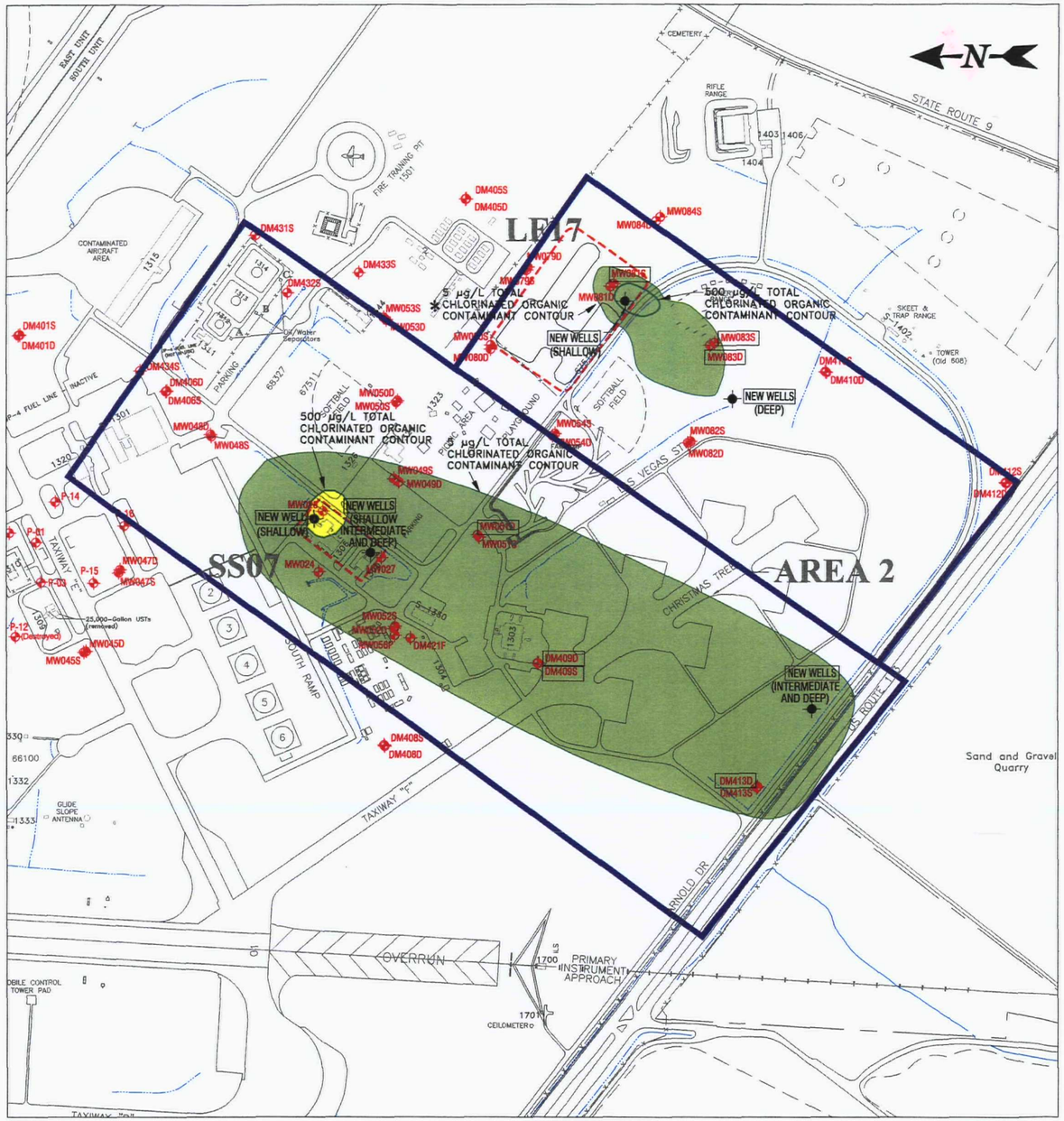
- The Delaware DNREC has established a GMZ around DAFB and adjacent properties as documented in the March 2003 DNREC Memorandum of Agreement (MOA) for Dover Air Force Base and Environs (DNREC, 2003). The GMZ is an internal DNREC mechanism whereby DNREC's Division of Water Resources, Well Permitting Section, ensures that no groundwater well permits are issued for use of the unconfined aquifer on-Base, or at specified off-Base areas around the perimeter of DAFB, without prior written approval from the DNREC Site Investigation and Restoration Branch. Areas restricted for well permitting under the GMZ include the off-Base area directly downgradient of the SMU sites. Maps depicting the restricted areas are included in DNREC's March 2003 MOA.

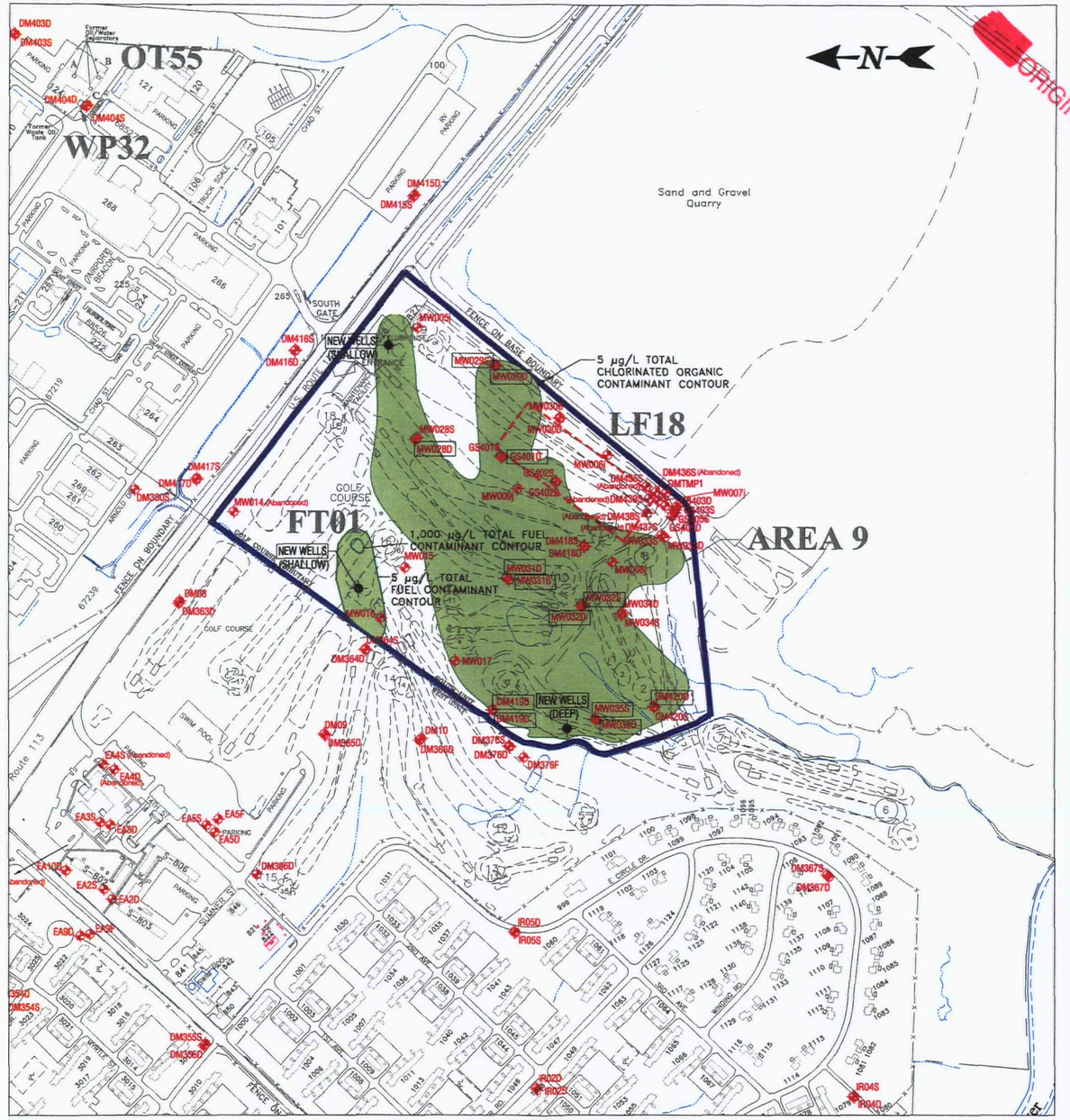
- The Air Force is responsible for all land use and activity restrictions and controls identified in this ROD with the exception of the GMZ which restricts well installation into portions of the unconfined aquifer on DAFB and surrounding areas as described above. The Delaware DNREC developed the GMZ and is responsible for any changes to it, and for implementing, overseeing, and enforcing the GMZ.

- All of the use and activity restrictions and controls set forth in this ROD shall remain in place until concentrations of hazardous substances at Sites LF17, SS07/Area 2, FT01, and LF18/Area 9 are shown to be at levels allowing for unrestricted exposure and unlimited use.

- Figure 3 is a map showing the on-Base area affected by SMU land use restrictions for both soil and groundwater. For soil, LUCs will be implemented with a 10-foot setback from the edge of Sites LF17, SS07, and LF18. For groundwater LUCs will be applied to the entire plume area at each site as shown in Figure 3. Maps showing the LUC areas and the areas affected by the DNREC GMZ will be included in the Base General Plan.

- DAFB personnel shall at least annually monitor and visually inspect all land use restrictions and controls specified in this ROD to evaluate the status of the LUCs, determine the effectiveness of and compliance with these restrictions and controls, and evaluate how any LUC deficiencies or inconsistent uses have been addressed. The inspections and monitoring will include determining any violations of the LUCs, as well as indications of tampering, trespass and incompatible use.





LEGEND:

- MW031S — Monitoring Well
- Direction of Groundwater Flow
- DM409D — Well to be monitored as part of remedy
- Proposed Monitoring Well

Note: Final locations of new wells and selection of the monitoring network wills be presented in the remedial action work plan

- LUCs for Soil, Set back distance 10 feet
- Accelerated Biodegradation
- Natural Attenuation
- On-Base LUCs for groundwater. Off-Base LUC boundary is defined in the DNREC GMZ.

0 600
SCALE IN FEET

CLIENT	DOVER AFB				TITLE: LAYOUT OF ALTERNATIVE A8 SMU, DAFB
PROJ	SMU ROD				
REVISION NO	0	DES BY	LS	12/06/05	URS
SCALE		DR BY	MS	12/06/05	PROJ NO / FIGURE 3
FILE		CHK BY	LS	12/06/05	

- An annual report of monitoring and inspection will be developed by DAFB and submitted on an information only basis to USEPA and DNREC, starting one year from the date of execution of this ROD. The report will briefly describe the measures by which the Base monitored and inspected the land use restrictions and controls specified in the ROD, state any violations or deficiencies and measures to address them, and assess whether the restrictions and controls have been complied with and whether Base implementing procedures are effective. The annual evaluation will address whether the owners and state and local agencies were notified of the use restrictions and controls affecting the property, and whether use of the property has conformed with such restrictions and controls. These annual monitoring reports will be used in preparation of the Five Year Review to evaluate the effectiveness of the remedy. This report shall also be filed in the Administrative Record.

- Any activity that is inconsistent with the land use restrictions, or any other action that may interfere with the effectiveness of the restrictions will be addressed by DAFB as soon as practicable, but in no case will the process be initiated later than ten (10) days after DAFB becomes aware of the breach.

- DAFB shall provide prompt notice to USEPA and DNREC if it discovers any activity that violates, is inconsistent with, or may interfere with the land use restrictions and controls specified in this ROD. The notice shall include any corrective measures taken or planned to address the violation, failure or deficiency. Verbal notice shall occur within three (3) calendar days of discovery, to be followed by written notice within ten (10) calendar days.

- DAFB shall obtain prior concurrence from USEPA and DNREC before modifying or terminating any land use restriction or control specified in the ROD. DAFB shall also obtain such regulator concurrence before any anticipated action that may disrupt the effectiveness of such land use restrictions and controls, or that may alter or negate the need for them.

- DAFB shall notify USEPA and DNREC at least 45 days in advance of any proposed land use changes that are inconsistent with the LUC objectives or the selected remedy in this ROD.

- DAFB shall maintain the integrity of any current and future remedial or monitoring system.

- The Air Force shall provide notice to USEPA and DNREC, consistent with the requirements of CERCLA § 120(h), at least six (6) months prior to any anticipated transfer or lease of property that includes LF17, SS02/Area 7, FT01, or LF18/Area 9 to a private, local, or state entity, and provide such regulators the opportunity to discuss with the Air Force appropriate provisions in the transfer or lease documents to maintain land use restrictions and controls. If notice within six months is not possible, the Air Force shall do so as soon as possible, but not later than sixty (60) days prior to such transfer or lease. The Air Force further

agrees to provide similar notice as to federal to federal transfer of property accountability and administrative control that includes LF17, SS02/Area 7, FT01, or LF18/Area 9. The Air Force shall provide a copy of an executed deed or transfer assembly to the USEPA and DNREC.

2.8.1.10 Additional Sampling

Additional sampling to better delineate or refine data for portions of the groundwater plumes at the SMU sites is a component common to all of the alternatives except Alternative A1 – the No Action alternative. This sampling is necessary in order to ensure source treatment is accomplished in appropriate areas and to determine optimum locations for monitoring well placement. This additional sampling consists of:

- Sampling and analysis to better define the downgradient edge of the LF17 groundwater plume.
- Sampling and analysis in the northeastern (upgradient) area of SS07/Area 2 and source treatment if a defined source is found.
- Sampling and analysis in the northeastern (upgradient) area of LF18/Area 9 to verify the absence or presence of a source area and source treatment if a defined source is located.

2.8.2 Common Elements and Distinguishing Features of Each Alternative

All of the alternatives, except A1 – No Action, are capable of meeting the RAOs discussed in Section 2.7, and will comply with ARARs. However, several of the alternatives must comply with additional action-specific or chemical-specific ARARs due to the nature of the treatment. Alternatives A3 (GRWs) and A5 (Pump and Treat) require compliance with the substantive requirements of the Delaware Regulations Governing Control of Air Pollution due to air emissions associated with the above-ground treatment systems. Alternative A5 also requires compliance with Clean Water Act pollutant discharge requirements due to the discharge of treated groundwater to surface water. Alternatives A6 (Chemical Oxidation), A7 (AB), and A8 (AB and Natural Attenuation with Monitoring) require compliance with the substantive requirements of the Delaware Regulations Governing Underground Injection Control due to the injection of substrate materials into the aquifer.

All of the alternatives except A1 are considered reliable in the long term. Only two of the alternatives, A3 and A5, would have residues requiring off-site disposal. These residues are in the form of spent activated carbon for both alternatives, and in the case of A5, small volumes of sludge associated with metals pre-treatment.

Estimated time to design and construct is moderate for all of the alternatives (excluding A1 which requires none), with alternatives A2, A7, and A8 requiring more limited design and less time to implement than alternatives A3, A4, A5, and A6. Of the eight

alternatives evaluated, alternative A5 is a presumptive remedy, and A3, A4, A7, and A8 involve the use of innovative technologies.

Comparisons of time to reach RAOs and costs for each alternative are included in Sections 2.9.5 and 2.9.7, respectively.

2.8.3 Expected Outcomes of Each Alternative

Given that alternative A1 is no action, by definition there would be no reduction in risk, no restrictions on use of land or groundwater, and no control over human exposure to contamination.

Alternatives A2 through A8 all include land use restrictions and controls. Under these alternatives, land use at LF17 and SS07/Area 2 would remain available for industrial use, land use at LF18 would remain unchanged from current recreational use, and land use at FT01 would be unrestricted for industrial or residential use.

Alternatives A2 through A8 will all result in the availability of the Columbia Aquifer on-Base for drinking water use. The time to achieve this use varies for each alternative as discussed in Section 2.9.5.

2.9 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In the FS for the SMU (USACE, 2005a), the eight alternatives discussed in Section 2.8 of this ROD were comparatively evaluated to determine the most suitable option capable of achieving the RAOs. The nine standard criteria used in this evaluation are described in Table 7. The first two criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs, are threshold criteria. Any alternative must be both protective and comply with ARARs before it can be considered as a remedy. The next five criteria – Long-term Effectiveness and Permanence; Reduction of Toxicity, Mobility, or Volume through Treatment; Short-term Effectiveness; Implementability; and Cost – are balancing criteria. The relative merits and tradeoffs among the alternatives are evaluated with these five criteria. The remaining two criteria, State Agency Acceptance and Community Acceptance, are modifying criteria that are addressed after agency and public comments have been received.

Table 7. Remedy Evaluation Criteria

1	***Overall Protection of Human Health and the Environment*** determines whether an alternative eliminates, reduces, or controls threats to public health and the environment.
2	***Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)*** evaluates whether the alternative meets federal and State environmental statutes, regulations, and other requirements that are applicable or relevant and appropriate to the site, or whether a waiver is justified. Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations which are collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4).

Table 7. Remedy Evaluation Criteria (cont'd)

3	***Long-term Effectiveness and Permanence*** considers the ability of an alternative to maintain protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.
4	***Reduction of Toxicity, Mobility, or Volume of Contaminants Through Treatment*** evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
5	***Short-term Effectiveness*** considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation and operation until cleanup levels are achieved.
6	***Implementability*** considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
7	***Cost*** includes estimated capital and annual O&M costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value.
8	***State/Support Agency Acceptance*** considers whether the State agrees with or opposes the preferred alternative.
9	***Community Acceptance*** considers whether the local community agrees with or opposes the preferred alternative. Comments received on the SMU Proposed Plan are an important indicator of community acceptance and are documented in this ROD.

Table 8 summarizes the salient details of the comparative analysis of alternatives. Evaluations of the alternatives against each of the nine criteria are discussed in more detail in the following subsections.

2.9.1 Overall Protection of Human Health and the Environment

This criterion addresses whether each alternative provides adequate protection of human health and the environment, and describes how risks are eliminated, reduced, or controlled, through institutional controls, engineering controls, or treatment. There are no risks to the environment from the SMU sites. Therefore the analysis focuses on protection of human health. All of the alternatives, except the No Action alternative, are protective of human health by reducing or controlling risks from the SMU sites through treatment of groundwater contaminants and implementation of LUCs.

- A1 (No Action) is not protective of human health because it does not contain provisions to eliminate or reduce contamination, nor does it include LUCs to prevent or control human exposure to contaminated soil or groundwater. It also contains no provision to monitor any of the groundwater contaminant plumes, and consequently compliance with RAOs cannot be assessed and future protection cannot be ensured. Therefore, A1 (No Action) will not be considered further in this analysis.

- A2 (Natural Attenuation with Monitoring) would provide adequate protection of human health by reducing groundwater contaminant levels, although extended periods of time are estimated to be required to achieve RAOs in the source areas for some of the sites. Degradation rates at SS07/Area 2 are insufficient to prevent off-Base migration of the plume above MCLs/RAOs. LUCs would eliminate or control risks to humans from potential exposure to contamination.

TABLE 8. Comparative Analysis of Alternatives

Criterion	Alternative A1	Alternative A2	Alternative A3	Alternative A4	Alternative A5	Alternative A6	Alternative A7	Alternative A8
Description	No Action	Natural Attenuation	Groundwater Recirculation Wells	Permeable Reactive Barriers	Groundwater Extraction and Treatment using Air Stripping (Pump & Treat)	*In Situ* Chemical Oxidation	Injection / Diffusion Accelerated Bioremediation	Injection / Diffusion AB and Natural Attenuation
Overall Protection								
• Human Health Protection	No Action is not protective of human health. It provides no means of reducing contamination or restricting exposure.	Natural attenuation reduces contaminant concentrations over time. LUCs ensure protectiveness during the remediation period.	GRW and natural attenuation reduces contaminant concentrations over time. LUCs ensure protectiveness during the remediation period.	PRB and natural attenuation reduces contaminant concentrations over time. LUCs ensure protectiveness during the remediation period.	Groundwater extraction and treatment combined with natural attenuation reduces contaminant concentrations over time. LUCs ensure protectiveness during the remediation period.	Chemical oxidation treatment combined with natural attenuation reduces contaminant concentrations over time. LUCs ensure protectiveness during the remediation period.	AB treatment combined with natural attenuation reduces contaminant concentrations over time. LUCs ensure protectiveness during the remediation period.	AB treatment combined with natural attenuation reduces contaminant concentrations over time. LUCs ensure protectiveness during the remediation period.
• Environmental Protection	The Basewide Ecological Risk Assessment indicates that there are no elevated risks to ecological receptors from SMU contaminants in any media, including groundwater.	The Basewide Ecological Risk Assessment indicates that there are no elevated risks to ecological receptors from SMU contaminants in any media, including groundwater.	The Basewide Ecological Risk Assessment indicates that there are no elevated risks to ecological receptors from SMU contaminants in any media, including groundwater.	The Basewide Ecological Risk Assessment indicates that there are no elevated risks to ecological receptors from SMU contaminants in any media, including groundwater.	The Basewide Ecological Risk Assessment indicates that there are no elevated risks to ecological receptors from SMU contaminants in any media, including groundwater. Groundwater released to surface water through pump and treat operations will meet surface water quality criteria.	Where chemical oxidizing agent is injected near a groundwater discharge location, care will be taken to ensure complete reaction prior to discharge to a surface water body.	The Basewide Ecological Risk Assessment indicates that there are no elevated risks to ecological receptors from SMU contaminants in any media, including groundwater.	The Basewide Ecological Risk Assessment indicates that there are no elevated risks to ecological receptors from SMU contaminants in any media, including groundwater.
Compliance with ARARs								
• Chemical-Specific ARARs	No chemical-specific ARARs would be met.	Natural attenuation is considered capable of achieving MCL compliance.	GRW treatment combined with natural attenuation is considered capable of achieving MCL compliance.	The combination of PRB treatment and natural attenuation is capable of achieving MCL compliance.	Pump and treatment of the groundwater combined with natural attenuation is considered capable of achieving MCL compliance.	Chemical oxidation treatment of the groundwater combined with natural attenuation is considered capable of achieving MCL compliance. Additions to the aquifer will comply with DNREC underground injection regulations.	AB treatment of the groundwater combined with natural attenuation is considered capable of achieving MCL compliance. Additions to the aquifer will comply with DNREC underground injection regulations.	AB treatment of the groundwater combined with natural attenuation is considered capable of achieving MCL compliance. Additions to the aquifer will comply with DNREC underground injection regulations.
• Action-Specific ARARs	There would be no action involved, therefore action-specific ARARs would not be triggered.	Long-term groundwater monitoring is provided.	Complies with Delaware Regulations Governing Hazardous Waste (DRGHW) for active land treatment. Long-term groundwater monitoring provided. Vacuum system will comply with the Delaware Regulations Governing Control of Air Pollution (DRGCAP).	Complies with DRGHW for active land treatment. Long-term groundwater monitoring provided.	Discharge to surface water will comply with Clean Water Act discharge requirements. Air stripper system will comply with DRGCAP requirements. Long-term groundwater monitoring provided.	The process will be operated in compliance with the substantive requirements for land treatment under DRGHW part 264, Subpart M. Post-treatment groundwater monitoring will be conducted according to Subpart F.	The process will be operated in compliance with the substantive requirements for land treatment under DRGHW part 264, Subpart M. Post-treatment groundwater monitoring will be conducted according to Subpart F.	The process will be operated in compliance with the substantive requirements for land treatment under DRGHW part 264, Subpart M. Post-treatment groundwater monitoring will be conducted according to Subpart F.

TABLE 8. Comparative Analysis of Alternatives (cont'd)

Criterion	Alternative A1	Alternative A2	Alternative A3	Alternative A4	Alternative A5	Alternative A6	Alternative A7	Alternative A8
Long-term Effectiveness and Permanence								
• Magnitude of Risk	This alternative provides no mechanisms to determine whether the RAOs are achieved over time.	Natural attenuation will reduce contaminant concentrations over time thereby reducing the magnitude of potential risk. In addition, because DAFB is expected to remain active for the foreseeable future, the LUCs provided under this alternative also provide protection of human health.	GRW treatment combined with natural attenuation will reduce contaminant concentrations over time thereby reducing the magnitude of potential risk. In addition, because DAFB is expected to remain active for the foreseeable future, the LUCs provided under this alternative also provide protection of human health.	PRB treatment combined with natural attenuation will reduce contaminant concentrations over time thereby reducing the magnitude of potential risk. In addition, because DAFB is expected to remain active for the foreseeable future, the LUCs provided under this alternative also provide protection of human health.	Groundwater extraction and treatment combined with natural attenuation will reduce contaminant concentrations over time thereby reducing the magnitude of potential risk. In addition, because DAFB is expected to remain active for the foreseeable future, the LUCs provided under this alternative also provide protection of human health.	Chemical oxidation treatment combined with natural attenuation will reduce contaminant concentrations over time thereby reducing the magnitude of potential risk. In addition, because DAFB is expected to remain active for the foreseeable future, the LUCs provided under this alternative also provide protection of human health.	AB treatment will reduce contaminant concentrations over time thereby reducing the magnitude of potential risk. In addition, because DAFB is expected to remain active for the foreseeable future, the LUCs provided under this alternative also provide protection of human health.	AB treatment combined with natural attenuation will reduce contaminant concentrations over time thereby reducing the magnitude of potential risk. In addition, because DAFB is expected to remain active for the foreseeable future, the LUCs provided under this alternative also provide protection of human health.
• Reliability of Controls	There would be no controls.	Natural attenuation treatment is considered reliable. Long-term monitoring will provide a method to monitor changes in the contaminant plumes. LUCs enforced by DAFB and DNREC are considered extremely reliable in preventing groundwater exposure.	The GRW technology is considered reliable. High efficiency removal of the polychlorinated contaminants will be required because operation of the system will create/maintain an aerobic condition within the aquifer in the source areas. The effectiveness will be influenced by local geologic conditions. LUCs enforced by DAFB and DNREC are considered extremely reliable in preventing groundwater exposure.	Reductions achieved via abiotic reactions catalyzed by the reactive metal will supplement the active natural attenuation processes. The treatment processes are considered reliable. LUCs enforced by DAFB and DNREC are considered extremely reliable in preventing groundwater exposure.	The extraction system will establish hydraulic control over the source areas in a relatively short time preventing the transport of contaminants beyond the capture zone. The proposed technologies are proven and highly reliable. LUCs enforced by DAFB and DNREC are considered extremely reliable in preventing groundwater exposure.	The reliability of chemical oxidation treatment is a function of the oxidizing agent delivery system, though it is expected to be designed and implemented properly and thus reliably. LUCs enforced by DAFB and DNREC are considered extremely reliable in preventing groundwater exposure.	The reliability of AB treatment is a function of the carbon substrate or oxidizing agent delivery system, though it is expected to be designed and implemented properly and thus reliably. LUCs enforced by DAFB and DNREC are considered extremely reliable in preventing groundwater exposure.	The reliability of AB treatment is a function of the carbon substrate delivery system, though it is expected to be designed and implemented properly and thus reliably. Natural attenuation is a reliable process. LUCs enforced by DAFB and DNREC are considered extremely reliable in preventing groundwater exposure.
Reduction of Toxicity, Mobility, and Volume								
• Treatment Process Used	Not applicable.	Natural attenuation processes include biodegradation, volatilization, dispersion, adsorption, and dilution, but are not considered a treatment process under the NCP.	Source area and plume boundary treatment using GRW. Distal ends of plumes treated by natural attenuation processes.	Majority of plume treated by natural attenuation. At Base boundary, plumes treated *in situ* via reductive dehalogenation.	Source area groundwater and plume boundary addressed by extraction followed by metals pretreatment and air stripping. Distal ends of plumes treated by natural attenuation processes.	Source area groundwater treated by chemical oxidation. Distal ends of plumes treated by natural attenuation processes.	Source area groundwater treated by AB. Distal ends of plumes treated by natural attenuation processes.	SS07/Area 2 source area groundwater treated by AB. Remaining sites and distal ends of plumes treated by natural attenuation processes.

TABLE 8. Comparative Analysis of Alternatives (cont'd)

Criterion	Alternative A1	Alternative A2	Alternative A3	Alternative A4	Alternative A5	Alternative A6	Alternative A7	Alternative A8
• Reduction in Toxicity, Mobility, and Volume Through Treatment	No treatment would be provided.	No treatment would be provided.	GRW process reduces groundwater toxicity in the source area. Contaminant mobility is increased briefly during treatment, but mobilized contaminant will be captured by the GRW gas collector system.	*In situ* reductive dehalogenation reduces groundwater toxicity.	Groundwater extraction will provide hydraulic control of the source areas thereby reducing the mobility of contaminants. Removal of volatile organic contaminants present in ground-water by air stripping will reduce the toxicity of groundwater. The volume of contaminated media is not affected.	*In situ* chemical oxidation reduces groundwater toxicity.	*In situ* AB treatment reduces groundwater toxicity.	*In situ* AB treatment reduces groundwater toxicity.
• Irreversibility of Treatment	Not applicable.	Natural attenuation will provide permanent removal of contaminants through irreversible processes, but is not considered a treatment process under the NCP.	GRW treatment results in permanent removal of contaminants through irreversible processes.	Reductive dehalogenation results in the permanent removal of contaminants through irreversible processes.	Air stripping treatment results in the permanent removal of contaminants through irreversible processes.	Chemical oxidation treatments result in the permanent removal of contaminants through irreversible processes.	AB treatments result in the permanent removal of contaminants through irreversible processes.	AB treatment results in the permanent removal of contaminants through irreversible processes.
• Type and Quality of Residue	Not applicable.	Not applicable.	Spent activated carbon will be generated if air treatment is required, though air treatment is not anticipated.	No residues generated.	Metals pretreatment generates small volumes of sludge which will require disposal. Spent activated carbon will be generated if air treatment is required, though air treatment is not anticipated.	No residues generated.	No residues generated.	No residues generated.
Short-term Effectiveness								
• Protection of Community During Remedial Action	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.	No short term impact on the community surrounding the site.
• Protection of Workers During Remedial Action	Not applicable.	Standard health & safety procedures and personal protective equipment will prevent exposure during well installations and sampling.	Standard health & safety procedures and personal protective equipment will prevent exposure during well installations and sampling.	Standard health & safety procedures and personal protective equipment will prevent exposure during construction.	Standard health & safety procedures and personal protective equipment will prevent exposure during well installations/sampling.	Standard health & safety procedures and personal protective equipment will prevent exposure during well installations/ sampling and chemical oxidation injection.	Standard health & safety procedures and personal protective equipment will prevent exposure during well installations/sampling and AB injections.	Standard health & safety procedures and personal protective equipment will prevent exposure during well installations/ sampling and AB injections.
• Environmental Impact	None.	Minimal disturbance will result from installing new monitoring wells. Environmental impacts related to construction are minimal.	Minimal to moderate land disturbance due to installment of a number of wells throughout the sites. Environmental impacts related to construction are minimal.	Moderate to extensive land disturbance due to installation of permeable reactive barriers and impermeable barriers. Environmental impacts related to construction are minimal.	Minimal to moderate disturbance is anticipated due to installation of groundwater extraction wells. Environmental impacts related to construction are minimal. Discharge of treated groundwater to surface water/storm sewer not expected to adversely impact the environment.	Minimal to moderate disturbance will result from installing new monitoring and injection wells. Environmental impacts related to construction are minimal.	Minimal to moderate disturbance will result from installing new monitoring and injection wells. Environmental impacts related to construction are minimal.	Minimal to moderate disturbance will result from installing new monitoring and injection wells. Environmental impacts related to construction are minimal.

TABLE 8. Comparative Analysis of Alternatives (cont'd)

Criterion	Alternative A1	Alternative A2	Alternative A3	Alternative A4	Alternative A5	Alternative A6	Alternative A7	Alternative A8
• Time Required to Achieve RAOs	Undefined. This alternative does not monitor for RAO compliance.	The estimated lengths of time required for contaminants to reach MCLs in the source area and throughout the downgradient (distal) plume area are: SS07/Area 2: 31 years (source), >50 years (distal) LF17: 20 years (source), 19 years (distal) FT01: 12 years (source), 12 years (distal) LF18/Area 9: 25 years (source), >50 years (distal)	The estimated lengths of time required for contaminants to reach MCLs in the source area and throughout the downgradient (distal) plume area are: SS07/Area 2: 5 years (source), >50 years (distal) LF17: 3 years (source), 18 years (distal) FT01: 2 years (source), 1 year (distal) LF18/Area 9: N/A years (source), 49 years (distal)	The estimated lengths of time required for contaminants to reach MCLs in the source area and throughout the downgradient (distal) plume area are: SS07/Area 2: N/A years (source), >50 years (distal) LF17: N/A years (source), N/A years (distal) FT01: N/A years (source), N/A years (distal) LF18/Area 9: N/A years (source), >50 years (distal)	The estimated lengths of time required for contaminants to reach MCLs in the source area and throughout the downgradient (distal) plume area are: SS07/Area 2: 25 years (source), >50 years (distal) LF17: 19 years (source), 4 years (distal) FT01: 11 years (source), <1 year (distal) LF18/Area 9: N/A years (source), 49 years (distal)	The estimated lengths of time required for contaminants to reach MCLs in the source area and throughout the downgradient (distal) plume area are: SS07/Area 2: 1 year (source), >50 years (distal) LF17: 1 year (source), 18 years (distal) FT01: 1 year (source), 1 year (distal) LF18/Area 9: N/A years source), N/A years (distal)	The estimated lengths of time required for contaminants to reach MCLs in the source area and throughout the downgradient (distal) plume area are: SS07/Area 2: 7 years (source), 42 years (distal) LF17: 20 years (source), 13 years (distal) FT01: 8 years (source), 8 years (distal) LF18/Area 9: N/A years (source), N/A years (distal)	The estimated lengths of time required for contaminants to reach MCLs in the source area and throughout the downgradient (distal) plume area are: SS07/Area 2: 7 years (source), 42 years (distal) LF17: 20 years (source), 19 years (distal) FT01: 12 years (source), 12 years (distal) LF18/Area 9: 25 years (source), >50 years (distal)
Implementability								
• Ability to Construct and Operate Technology	Not applicable.	This alternative requires the installation of new monitoring wells. No difficulties are anticipated.	No unusual difficulties are anticipated in installation of the GRW wells or equipment. Operation of the system is straightforward.	The construction of a PRB system may be disruptive to utilities at SS07/Area 2. No other unusual difficulties are anticipated installing the system.	No difficulties are anticipated in construction of groundwater extraction wells and operation of selected technologies.	Utility avoidance is the primary concern. No other difficulties are anticipated in connection with the chemical oxidation technology.	Utility avoidance is the primary concern. No other difficulties are anticipated in connection with the AB treatment technology.	Utility avoidance is the primary concern. No other difficulties are anticipated in connection with the AB treatment technology.
• Reliability of Technology	Not applicable.	Study confirms ongoing natural attenuation in the SMU. Continued and comparable attenuation of contaminants in the SMU is anticipated in the future.	GRW is a reliable technology for removal and destruction of VOCs in homogeneous permeable soils. However, presence of clay layers in the SMU may reduce the reliability of this technology.	Hydrology of the system must be carefully designed to prevent groundwater from backing up behind the funnel and bypassing the gate. The reactive barrier technology is innovative and field tests confirm its reliability.	Pump and treat systems operate reliably, though slowly.	The reliability of the chemical oxidation technology is a function of the oxidizing agent delivery system. Subsurface features may impair uniform distribution and may reduce the reliability of this technology.	The reliability of the AB technology is a function of the reagent delivery system. Subsurface features may impair uniform distribution and may reduce the reliability of this technology.	Study confirms ongoing natural attenuation in the SMU. Continued and comparable attenuation of contaminants in the SMU is anticipated in the future. The reliability of the AB technology is a function of the reagent delivery system. Subsurface features may impair uniform distribution and may reduce the reliability of this technology.
• Ease of Undertaking Additional Action	Not applicable.	Additional actions could easily be performed if necessary.	If contaminant levels increase after remediation is complete, additional remediation can be performed by restarting the treatment system. The GRW well networks may be expanded or replaced with new technologies if necessary.	Placement of the PRBs is permanent. However, additional actions could easily be performed if necessary.	If contaminant levels increase after remediation is complete, additional remediation can be performed by restarting the treatment system. The extraction network and/or treatment system could be expanded or augmented if necessary, or replaced with new technologies.	If contaminant levels increase after remediation is complete, additional remediation can be performed by performing additional injections. The chemical oxidation well networks may be expanded or replaced with new technologies if necessary.	If contaminant levels increase after remediation is complete, additional remediation can be performed by performing additional injections. The AB injection networks may be expanded or replaced with new technologies if necessary.	Additional actions could easily be performed if necessary.

TABLE 8. Comparative Analysis of Alternatives (cont'd)

Criterion	Alternative A1	Alternative A2	Alternative A3	Alternative A4	Alternative A5	Alternative A6	Alternative A7	Alternative A8
• Ability to Monitor	Not applicable.	Performance of natural attenuation is easily monitored.	Performance of the GRW system is easily monitored.	Performance of the PRBs is easily monitored.	Performance of the pump and treat systems are easily monitored.	Performance of chemical oxidation is easily monitored.	Performance of AB treatment is easily monitored.	Performance of AB treatment and natural attenuation is easily monitored.
• Regulatory Agency Coordination/ Approval	None.	Groundwater wells will require State permits.	Groundwater wells will require State permits.	Groundwater wells will require State permits.	Effluent limits set by National Pollutant Discharge and Elimination System (DNREC's) NPDES branch have to be met prior to discharge to surface water. Groundwater wells will require State permits.	Additions to the aquifer will comply with DNREC underground injection regulations. Groundwater wells will require State permits.	Additions to the aquifer will comply with DNREC underground injection regulations. Groundwater wells will require State permits.	Additions to the aquifer will comply with DNREC underground injection regulations. Groundwater wells will require State permits.
• Availability of Services	Not applicable.	Readily available.	The GRW system installation will require a specialty contractor, however, the remaining portions of this alternative are readily available.	Installation of the reactive barrier will require a specialty contractor.	Readily available.	Readily available.	Readily available.	Readily available.
• Availability of Equipment	Not applicable.	Readily available.	Readily available.	Readily available.	Readily available.	Readily available.	Readily available.	Readily available.
• Availability of Technology	Not applicable.	In place.	Readily available.	Readily available.	Readily available.	Readily available.	Readily available.	Readily available.
Cost								
Capital Cost	$-0-	$150,000	$3,500,000	$16,000,000[a]	$2,000,000	$970,000[b]	$420,000[b]	$280,000
Annual O&M Cost	$-0-	$110,000	$330,000	$140,000[a]	$360,000	$490,000[b]	$160,000[b]	$150,000
Net Present Worth Cost (c)	$-0-	$1,600,000	$7,400,000	$19,000,000[a]	$7,600,000	$2,300,000[b]	$1,400,000[b]	$1,800,000
State Acceptance	The State of Delaware has expressed its support of the active remedies except for Alternative A2, which appeared to be inadequate in meeting the RAOs in the short-term at SS07/Area 2.							
Community Acceptance	The community did not express any opinions on the selected remedy.							

(a) Only includes costs for remediation of SS07/Area 2 and LF18/Area 9. Remediation of LF17 and FT01 not included.
(b) Only includes costs for remediation of SS07/Area 2, LF17, and FT01. Remediation of LF18/Area 9 not included.
(c) All costs rounded to two significant figures.
DRGHW - Delaware Regulations Governing Hazardous Waste
DRGCAP - Delaware Regulations Governing Control of Air Pollution
NPDES - National Pollutant Discharge and Elimination System

- A3 (GRWs) would provide excellent protection of human health and would reduce groundwater contaminant levels in the source areas of SS07/Area 2, LF17, and FT01 relatively quickly. LUCs would eliminate or control risks to humans from potential exposure to contamination at all four SMU sites. However, the release of dissolved oxygen into the plumes may hinder any natural anaerobic (low oxygen) biodegradation processes that are occurring both in the source area and in the downgradient plume.

- A4 (PRBs) would provide adequate protection of human health and the environment for SS07/Area 2 and LF18/Area 9 where PRBs are applicable for installation. LUCs would eliminate or control risks to humans from potential exposure to contamination at all four SMU sites. However, as a barrier technology (with PRBs installed at the downgradient ends of the plumes), this alternative would not reduce contaminant concentrations any faster than other alternatives that rely on plume migration for treatment such as natural attenuation.

- A5 (Pump & Treat) would provide adequate protection of human health and offers similar protection to other alternatives that rely on plume migration for treatment such as natural attenuation and PRBs. LUCs would eliminate or control risks to humans from potential exposure to contamination.

- A6 (Chemical Oxidation) would provide excellent protection of human health and would provide the most rapid remediation of the source areas of SS07/Area 2, LF17, and FT01. LUCs would eliminate or control risks to humans from potential exposure to contamination. Chemical oxidation is a below ground destructive process that would decrease contaminant concentrations to achieve RAOs within 1 year in the source areas of these sites. However, the release of dissolved oxygen into the plumes may hinder any natural anaerobic (low oxygen) biodegradation processes that are occurring both in the source area and in the downgradient plume.

- A7 (AB) would provide good protection of human health and the environment at sites where applied (SS07/Area 2, LF17, and FT01). This is a destructive, below ground process. The AB process is projected to hasten the remediation of the SS07/Area 2 source relative to natural attenuation, although the benefit provided to the source remediation of LF17 and FT01 is less clear. LUCs would eliminate or control risks to humans from potential exposure to contamination.

- A8 (AB and Natural Attenuation with Monitoring) would provide good protection of human health and the environment, combining the advantages of AB treatment of SS07/Area 2 offered by A7 and the advantages of natural attenuation treatment offered by A2 for all other sites/areas. LUCs would eliminate or control risks to humans from potential exposure to contamination.

2.9.2 Compliance with ARARs

Section 121(d) of CERCLA and NCP § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, or ARARs, unless such ARARs are waived under CERCLA section 121(d)(4). The "Compliance with ARARs" criterion evaluates whether a remedy will meet all ARARs, or provides a basis for invoking a waiver. Attachment 2 is a list of the ARARs applicable to each site and each of the evaluated alternatives.

Key chemical–specific ARARs applicable to all alternatives are the federal MCLs for the chemicals of concern as listed in Table 6, and the State cleanup levels under the Delaware Hazardous Substance Cleanup Act (HSCA) and the Delaware Regulations Governing Hazardous Substance Cleanup (DRGHSC). In general, under the DRGHSC, for unrestricted land use, when there are multiple contaminants at a site, the compliance cleanup level for each contaminant is such that the sum of the risks posed by the contaminants shall not exceed 1×10^{-5} cancer risk or a hazard index value of one; however, MCLs may also be used as the cleanup levels under the State regulations. Less stringent conditional cleanup levels may also be used under the DRGHSC which are protective of public health, welfare, and the environment under restricted land use conditions.

Action-specific ARARs associated with alternatives A6, A7, and A8 include compliance with the substantive requirements of the Delaware Regulations Governing Underground Injection Control because these alternatives involve injection of substrate materials into the aquifer. Additional action-specific ARARs are associated with Alternatives A3 and A5. Both A3 and A5, require compliance with the substantive requirements of the Delaware Regulations Governing Control of Air Pollution due to air emissions associated with the above-ground treatment systems. A5 also requires compliance with Clean Water Act requirements for discharge to surface water due to the discharge of treated groundwater into the Base stormwater drainage system.

Alternatives A2 through A8 would all achieve compliance with ARARs, though the time required to meet groundwater RAOs varies between alternatives as discussed in Section 2.9.5.

2.9.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence criterion considers the magnitude of residual risk that would remain after the implementation of an alternative, and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. Alternatives A2 through A8 provide for the long-term protection of human health on-Base through LUCs and off-Base through DNREC's GMZ. The treatments provided by Alternatives A2 through A8 are all considered adequate and reliable.

2.9.4 Reduction of Toxicity, Mobility, or Volume of Contaminants Through Treatment

Alternatives A3 through A8 all use treatment to reduce toxicity, mobility, or volume of contaminants and therefore satisfy the preference for active treatment. Alternative A2 can reduce toxicity and volume of contaminants, but is not considered a treatment process under the NCP. For a brief discussion of each alternative, see Table 8.

2.9.5 Short-Term Effectiveness

Short-term effectiveness examines the period of time needed to implement the remedy, impacts to workers and the community and environmental health during construction and operation of the remedy, and the time required to achieve RAOs. None of the alternatives will significantly impact either worker or community or environmental health. Therefore, the evaluation of this criterion focuses on the estimated remediation times.

A summary of the estimated remediation times for each alternative is presented in Table 9. Separate remediation times are estimated for the source areas and downgradient portions of the plumes. The primary differences in estimated times are found in the comparison of source remediation times. The downgradient plume remediation times tend to be extended, especially for SS07/Area 2 and LF18/Area 9 where large areas are impacted by relatively low level contamination that cannot be treated aggressively in a reasonable manner.

Table 9. Times to Achieve RAOs (in years)

Alternative	LF17	SS07/ Area 2	FT01	LF18/ Area 9
A1	(a)	(a)	(a)	(a)
A2	20/19	31/ >50	12/12	25/ >50
A3	3/18	5/ >50	2/1	NE/49
A4	NE	NE/ >50	NE	NE/ >50
A5	19/4	25/ >50	11/ <1	NE/49
A6	1/18	1/ >50	1/1	NE
A7	20/13	7/42	8/8	NE
A8	20/19	7/42	12/12	25/ >50

(a) Unknown time frame
NE - Not evaluated
Note: RAO times are given for the source area of a plume followed by the downgradient portion of a plume.

Source plume remediation would be accomplished most rapidly by A6 (Chemical Oxidation) and A3 (GRWs). These alternatives most aggressively remediate contaminants, achieving RAOs in the source areas within an estimated range of 1 to 5 years. However, the rapid source remediation times do not result in significant, if any, reductions in downgradient plume remediation times, which are projected to require on the order of 50 years for SS07/Area 2.

A7 (AB) and A8 (AB and Natural Attenuation with Monitoring) are considered the next most effective source control alternatives, primarily based on the estimated remediation time for the SS07/Area 2 source of 7 years. However, AB treatment provides little additional benefit to the remediation of the LF17 or FT01 sources over natural attenuation alone. AB treatment may allow the downgradient plume of SS07/Area 2 to attenuate a bit faster (42 years) than would be achieved under A3 or A6 because it would not result in oxygenating the aquifer, which could disrupt the established anaerobic (low oxygen) biochemical degradation processes.

Overall, A2 (Natural Attenuation), A4 (PRBs), and A5 (Pump & Treat) provide the least rapid source remediation times, as would be expected of alternatives relying on natural groundwater flow to transport contaminants for treatment. However, when the projected remediation times of both the source and downgradient plumes are considered, these flow-based alternatives do not significantly under-perform other alternatives.

2.9.6 Implementability

The main factors considered for this criterion are technical feasibility and administrative feasibility. The concept of administrative feasibility includes such implementation actions as modifying the Base General Plan to identify LUCs and coordinating specific LUC language issues, and complying with annual LUC monitoring and reporting requirements with federal and state regulators, and availability of required services and materials. All alternatives are administratively feasible. Therefore, the focus of this comparison is on the technical feasibility of implementing the alternatives.

A2 (Natural Attenuation) has only minimal technical considerations (simple installation of monitoring wells). A3, A4, and A5 are the most complex systems to design, construct, and operate. A6, A7, and A8 require the installation of injection points and monitoring wells. Of these three, A6 is the most complex to implement because of the larger number of injection points.

2.9.7 Cost

The costs associated with each alternative are summarized in Table 10. Capital costs reflect the estimated expenses for construction or implementation of a remedy including equipment, supplies, and labor. The annual O&M costs are those required for routine maintenance of equipment and regular monitoring of a remedy's performance, which includes periodic groundwater sampling. Present worth is the total remedy cost (capital and O&M) assuming that the funds set aside today would grow at a certain percentage rate and that the annual O&M costs would remain unchanged over the years of remedy operation. A discount rate of 4 percent was used in this calculation.

ORIGINAL

Table 10. Cost Summary

Alternative	Capital Cost	Annual O&M	Present Worth
A1	$0	$0	$0
A2	$153,000	$112,000	$1,550,000
A3	$3,540,000	$330,700	$7,440,000
A4	$16,500,000	$137,000	$18,800,000
A5	$2,050,000	$361,000	$7,630,000
A6	$970,000	$492,000	$2,280,000
A7	$420,000	$159,000	$1,400,000
A8	$281,000	$154,000	$1,800,000

The simple comparison of alternative costs in Table 10 is somewhat misleading because the alternatives do not all address the same sites; some of the alternatives are only applicable to selected site groupings. In order to more fully assess remediation costs, a breakdown of costs by site is presented in Table 11. When the SMU-wide remedy is implemented, each site will need to be addressed. Several of the alternatives which only address some of the SMU sites would have to be supplemented with other alternatives. For example, if Alternative 4 is selected for implementation ($18.8 million net present worth), another alternative would still need to be selected to address LF17 and FT01. Thus, the costs presented in Tables 10 and 11 for A4, A6, and A7 under-report the complete SMU remedial cost. Taking this into account, alternatives A2, A7, and A8 are ranked best for the cost criterion, with A6 considered adequate for cost, and A3, A4, and A5 ranked as poor for the cost criterion.

2.9.8 State Agency Acceptance

The Delaware DNREC supports the selection of Alternative A8 (AB, Natural Attenuation with Monitoring, and LUCs) for the SMU sites.

2.9.9 Community Acceptance

Community acceptance of the selected alternative, A8 (AB, Natural Attenuation with Monitoring, and LUCs) was evaluated after the public comment period for the Proposed Plan ended. As described in Part III - Responsiveness Summary of this ROD, no comments or request for a public meeting were received.

2.10 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that treatment will be used to address the principal threats (i.e. source material that is highly toxic and/or highly mobile) posed by a site wherever practicable. No principal threat wastes have been identified at any of the SMU sites.

TABLE 11. Action Alternatives Cost Summary by Site

Alternative	2. Natural Attenuation	3. GRW	4. Permeable Reactive Barier	5. Groundwater Extraction with Air Stripping	6. Chemical Oxidation	7. Accelerated Bioremediation	8. Accelerated Bioremediation and Natural Attenuation
				Area 2 / SS07			
Capital Cost	$86,000	$660,000	$4,400,000	$440,000	$500,000	$210,000	$210,000
Annual O&M	$35,000	$74,500	$61,000	$75,500	$294,000	$77,000	$77,000
Present Worth	$550,000	$1,300,000	$5,430,000	$1,540,000	$1,390,000	$800,000	$800,000
				LF17			
Capital Cost	$30,000	$690,000	not applicable	$460,000	$320,000	$150,000	$30,000
Annual O&M	$18,000	$57,500	not applicable	$58,500	$172,000	$64,500	$18,000
Present Worth	$200,000	$960,000	not applicable	$1,160,000	$710,000	$450,000	$190,000
				FT01			
Capital Cost	$11,000	$690,000	not applicable	$410,000	$150,000	$60,000	$11,000
Annual O&M	$9,000	$48,500	not applicable	$53,500	$26,500	$17,500	$9,000
Present Worth	$90,000	$790,000	not applicable	$870,000	$180,000	$150,000	$90,000
				Area 9 / LF18			
Capital Cost	$26,000	$1,500,000	$12,100,000	$740,000	not applicable	not applicable	$30,000
Annual O&M	$50,000	$153,200	$76,000	$173,700	not applicable	not applicable	$50,000
Present Worth	$710,000	$4,390,000	$13,350,000	$4,060,000	not applicable	not applicable	720,000
				TOTAL			
Capital Cost	$153,000	$3,540,000	$16,500,000	$2,050,000	$970,000	$420,000	$281,000
Annual O&M	$112,000	$333,700	$137,000	$361,200	$492,500	$159,000	$154,000
Present Worth	$1,550,000	$7,440,000	$18,780,000	$7,630,000	$2,280,000	$1,400,000	$1,800,000

2.11 SELECTED REMEDY

2.11.1 Summary of the Rationale for the Selected Remedy

Alternative A8 (AB, Natural Attenuation with Monitoring, and LUCs) is the selected remedial alternative for the SMU sites based on the comparison of alternatives discussed in Section 2.9. All of the alternatives except no action (A1) are protective of human health and the environment, will comply with ARARs, and will meet RAOs. Alternative A8 is recommended based on the best blend of effectiveness, implementability, and cost. With AB treatment of the SS07/Area 2 source under alternative A8, the estimated remediation time for the source area is significantly improved as compared to natural attenuation alone, yet the cost of the A8 alternative is significantly less than other alternatives that would provide source area treatment with only slightly better source area remediation times. The present worth cost of this alternative ($1.8 million) in general provides a significant cost advantage over most of the other alternatives, considering that the overall site remediation times under A8 are comparable to the overall remediation times offered by the other alternatives. The level of difficulty implementing A8 is expected to be lower than the level of difficulty to implement most of the other alternatives. In all, alternative A8 is judged to provide the best balance of tradeoffs among the nine evaluation criteria, and is therefore the selected alternative.

LUC performance objectives will protect human health and the environment while the active portion of the remedy is undertaken, by restricting land use at LF17 and SS07/Area 2 to industrial uses, with on-site day-care centers and recreation areas prohibited, and by preventing residential exposures to soil at LF18, until concentrations of hazardous substances at these sites are at levels allowing for unrestricted exposure and unlimited use. The LUC performance objectives will also prevent exposure to groundwater from the Columbia Aquifer near all four sites until such time as cleanup levels for the contaminants in the aquifer have been obtained and risks from groundwater use are shown to be reduced to allow for unrestricted exposure and unlimited use. Digging and other ground-disturbing activities at LF17, SS07/Area 2, LF18, and FT01 that are inconsistent with the objectives listed above are prohibited. The LUC performance objectives will also maintain the integrity of any current and future remedial or monitoring system. The LUC portion of the remedy is easily implemented and has very minimal costs associated with it.

2.11.2 Description of the Selected Remedy

The selected remedy for the SMU sites/areas is Alternative A8, AB, Natural Attenuation with Monitoring, and LUCs. The layout of this alternative across the SMU is shown in Figure 3. The estimated time frames to achieve RAOs using alternative A8 range from 7 to 25 years for source areas and from 12 to over 50 years for the downgradient portions of the plumes (Table 9). Alternative A8 includes the following major components:

- **Injection/Diffusion AB of the SS07/Area 2 source area.** AB will be applied where the concentrations of total chlorinated organic contaminants exceed 500

µg/L within the Area 2 plume. AB involves the injection of a carbon-containing substrate into the groundwater to create an anaerobic environment, thereby enhancing microbial activity and stimulating reductive dechlorination of the contaminants. Conceptually, injection points will be laid out on a grid pattern spaced at even intervals. For example, if 15-foot spacing is used between injection points, it will take approximately 106 injection points to cover the 500 µg/L contour area at SS07/Area 2. Exact placement and numbers of injection points, as well as substrate material and quantity, will be developed as part of the remedial action work plan for the SMU, which will be reviewed and approved by USEPA and DNREC. It is expected that periodic injections of substrate will be required over approximately four years.

- **Natural attenuation of LF17, FT01, LF18/Area 9, and the downgradient portion of the SS07/Area 2 plume.** Naturally occurring biological and physical processes will be allowed to reduce contaminant concentrations in all groundwater contaminant areas except the portion of the SS07/Area 2 plume that will be treated using AB. Evidence for the occurrence of these processes was discussed in Section 2.8.1.2. Groundwater monitoring will be conducted to verify the effectiveness of the natural attenuation remedy.

- **Groundwater monitoring.** Periodic groundwater monitoring will be accomplished at all four SMU sites. Approximately 11 new monitoring wells will be installed to supplement the existing well network, and groundwater monitoring will be performed on approximately 32 wells. The conceptual monitoring well networks, including recommendations for new wells, are shown for each site in Figure 3. Groundwater samples will be analyzed for chlorinated VOCs or aromatic hydrocarbons (fuel-related VOCs) as appropriate for each site. Analysis will also be performed for anaerobic biodegradation indicators (e.g., dissolved oxygen, redox potential, iron, etc.). The exact placement and number of monitoring wells, sampling frequency, and other monitoring details will be developed as part of the remedial action work plan for the SMU, and will be reviewed and approved by the USEPA and DNREC.

- **Additional sampling to delineate the downgradient edge of the LF17 plume.** The natural attenuation study of LF17, documented in the FS for the SMU (USACE, 2005a), did not define the downgradient edge of the LF17 plume. Additional sampling will be accomplished to define the downgradient edge of the LF17 plume for purposes of siting monitoring wells for the natural attenuation monitoring program. The sampling plan will be developed as part of the remedial action work plan for the SMU, and will be reviewed and approved by the USEPA and DNREC.

- **Additional sampling in the northeastern (upgradient) area of SS07/Area 2 and source treatment if a defined source is located.** A defined source for the upgradient portion of SS07/Area 2 has never been found. Additional sampling will be performed on the upgradient end of SS07/Area 2 to either verify that no

source area exists, or identify the location of a source area. Source treatment would be accomplished if a source is located. The sampling plan will be developed as part of the remedial action work plan for the SMU, and will be reviewed and approved by the USEPA and DNREC.

- **Additional sampling in the northeastern area of LF18/Area 9 and source treatment if a defined source is located.** A defined source for the upgradient portion of the Area 9 plume has never been found. Upgradient sampling accomplished during the RI extended to the golf course club house near U.S. Route 113. Additional sampling will be performed northeast of this area to either verify that no source area exists, or identify the location of a source area. Source treatment would be accomplished if a source is located. The sampling plan will be developed as part of the remedial action work plan for the SMU, and will be reviewed and approved by the USEPA and DNREC.

- **LUCs** for soil and groundwater as described in Section 2.8.1.9.

- **No further action** is required for the soil medium at FT01.

- **No action** is required for the surface water and sediment media in the SMU.

- The Air Force will evaluate the vapor intrusion pathway for the SMU sites during the groundwater remedial action phase of the cleanup program.

2.11.3 Summary of the Estimated Remedy Costs

A summary of the costs for the recommended alternative is provided in Table 12. The capital costs shown in the table are primarily associated with installation of monitoring wells at all sites, and the installation of injection points and initial carbon-substrate injection at SS07/Area 2. Subsequent substrate injections and periodic monitoring are considered O&M costs.

The costs shown in Table 12 are based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

TABLE 12. Cost Estimate for Alternative A8

Item	Unit Cost ($)	SS07/Area 2 Units	SS07/Area 2 Total ($)	LF17 Units	LF17 Total ($)	FT01 Units	FT01 Total ($)	LF18/Area 9 (Sources D & E) Units	LF18/Area 9 (Sources D & E) Total ($)
Capital Costs									
A. Construction Costs - HRC Placement									
Pilot Study	20,000 /each	1	20,000		0		0		0
Temporary Borehole and Injection Points	300 /point	106	31,800		0		0		0
HRC (1)	6 /pound	4,240	25,440		0		0		0
Subtotal			**77,240**		**0**		**0**		**0**
B. Monitoring Well Installation									
Shallow Monitoring Wells (2)	7,000 /well	2	14,000	1	7,000	1	7,000	1	7,000
Deep Monitoring Wells (2)	9,000 /well	4	36,000	1	9,000		0	1	9,000
Well Abandonment	2,000 /well	2	4,000	0	0		0	0	0
Subtotal			**$54,000**		**$16,000**		**$7,000**		**$16,000**
Total Construction Cost			**131,240**		**16,000**		**7,000**		**16,000**
Health & Safety Contingencies (2.5%)			3,300		400		200		400
Construction Contingencies (20%)			26,200		3,200		1,400		3,200
Design Engineering & Construction Management (35%)			45,900		5,600		2,500		5,600
Total Capital Cost (rounded)			**210,000**		**30,000**		**11,000**		**30,000**
Operation and Maintance Costs									
C. HRC Treatment (in 2nd year only)									
Temporary Borehole and Injection Points	300 /point	106	31,800		0		0		0
HRC per Point (1)	6 /pound	4,240	25,440		0		0		0
Health & Safety Contingencies (2.5%)			1,400		0		0		0
Construction Contingencies (20%)			11,400		0		0		0
Design Engineering & Construction Management (35%)			14,300		0		0		0
Subtotal (in 2nd year only)			**84,000**		**0**		**0**		**0**

TABLE 12. Cost Estimate for Alternative A8 (continued)

ORIGINAL

Operation and Maintance Costs (cont'd)		SS07/Area 2		LF17		FT01		LF18/Area 9 (Sources D & E)	
Item	Unit Cost ($)	Units	Total ($)	Units	Total ($)	Units	Total ($)	Units	Total ($)
D. HRC Treatment (in 4th year only)									
Temporary Borehole and Injection Points	300 /point	106	31,800		0		0		0
HRC per Point (1)	6 /pound	4,240	25,440		0		0		0
Health & Safety Contingencies (2.5%)			1,400		0		0		0
Construction Contingencies (20%)			11,400		0		0		0
Design Engineering & Construction Management (35%)			14,300		0		0		0
Subtotal (in 4th year only)			**84,000**		**0**		**0**		**0**
E. Monitoring Program - Semi-Annual Sampling (Year 1 through Year 5)									
Sample Collection	600 /well	20	12,000	10	6,000	4	2,400	30	18,000
Laboratory Analyses (3)	500 /sample	22	11,000	12	6,000	6	3,000	34	17,000
Sampling & Monitoring Report (4)	3,000 /6 wells	4	12,000	2	6,000	1	3,000	5	15,000
Total Annual Monitoring (rounded)			**$35,000**		**$18,000**		**$9,000**		**$50,000**
F. Monitoring Program - Annual Sampling (Year 6 until RAOs achieved)									
Sample Collection	600 /well	10	6,000	5	3,000	2	1,200	15	9,000
Laboratory Analyses (3)	500 /sample	11	5,500	6	3,000	3	1,500	17	8,500
Sampling & Monitoring Report (4)	3,000 /6 wells	2	6,000	1	3,000	1	3,000	3	9,000
Total Annual Monitoring (rounded)			**$18,000**		**$9,000**		**$6,000**		**$27,000**
Time to Reach RAOs (years)			42		19		12		50
Net Present Worth (rounded) (5)			**800,000**		**190,000**		**90,000**		**720,000**

(1) HRC = Hydrogen Release Compound . Vendor quote for costing purpose only, Regenesis 2003. Alternate material may be selected during the remedial design phase.
(2) The cost for a 35-foot shallow well is approximately $7,000 and the cost for a 65-foot deep well is approximately $9,000.
(3) Sampling includes quality assurance/quality control samples: 1 trip blank for every 4 samples collected and a field duplicate for every 10 samples collected. Analyses include VOCs, dissolved gases, and indicator parameters.
(4) Reporting costs assume $3,000 for every six wells in each round.
(5) Net present worth for SMU monitoring is based on a 4% interest rate and the time frames to reach RAOs.

2.11.4 Expected Outcomes of the Selected Remedy

Once the LUCs portion of the remedy is in place, land use at Sites LF17 and SS07/Area 2 will be restricted to industrial uses, land use at LF18 will remain recreational, but will be restricted from other residential use, and land use at FT01 will be unrestricted for industrial or residential use. The LUCs will remain in effect until concentrations of hazardous substances at these sites are shown to be at levels allowing for unrestricted exposure and unlimited use.

For contaminants in groundwater at all four sites/areas, natural attenuation or AB with natural attenuation will reduce concentrations to the RAOs established for each site. The RAOs, which are based on the federal MCLs for safe drinking water, are listed in Table 6. Thus, once the RAOs are achieved, on-Base groundwater from the Columbia Aquifer would be available for unrestricted use. Estimated times to achieve the RAOs vary by site and are listed in Table 9. Off-site migration of contaminated groundwater at levels exceeding MCLs will no longer be a concern once groundwater RAOs are achieved. Therefore restrictions on use of the Columbia Aquifer in off-Base areas identified in the DNREC GMZ for Dover AFB could be lifted, assuming there are no issues with non-Air Force off-Base sources of contamination.

2.12 STATUTORY DETERMINATIONS

This section provides a brief, site-specific description of how the selected remedy satisfies the statutory requirements of CERCLA Section 121 (as required by NCP §300.430(f)(5)(ii)) for protection of human health, compliance with ARARs, cost-effectiveness, and use of permanent solutions/alternative treatments/resource recovery technologies to the maximum extent practicable.

2.12.1 Protection of Human Health and Environment

The selected remedy for the SMU is protective of human health and the environment. It will achieve protection by reducing groundwater contaminant concentrations through treatment, thereby reducing risks posed by potential exposure to groundwater at the four SMU sites. Groundwater contaminants at all four sites will be reduced through natural attenuation processes and treated by AB at the SS07/Area 2 source area. Groundwater exposure levels will be reduced to protective ARAR levels via these remedial actions. LUCs will be implemented to prevent human exposure to contaminated groundwater until cleanup levels are achieved. LUCs will also be implemented to prevent or control potential human exposure to residual contaminants in soil, and prevent incompatible use of the sites. Implementation of this remedy will not pose any unacceptable short-term risks or cross-media impacts.

2.12.2 Compliance with ARARs

CERCLA Section 121(d)(2)(A) specifies that on-site remedial actions be evaluated to determine whether they meet standards, requirements, criteria, or limitations under any federal environmental law that is determined to be an ARAR. This provision also specifies that State ARARs must be met if they are more stringent than federal requirements.

ARARs are typically divided into three categories: 1) those that pertain to the management of certain chemicals; 2) those that control specific actions; and 3) those that restrict certain activities at a given location. Chemical-specific ARARs are typically numerical (risk-based) values or methodologies that establish limits on the concentrations of a chemical discharged to or found in the environment. Action-specific ARARs are technology or activity-based requirements and limitations on actions taken involving the management of hazardous wastes. Location-specific ARARs are restrictions placed on the conduct of activities in unique or sensitive areas to prevent damage in that area.

The selected remedy of AB, natural attenuation with monitoring, and LUCs, complies with federal and State ARARs. A comprehensive list of federal and State ARARs applicable to the SMU sites and the selected remedial alternative is included in Attachment 2. The major ARARs applicable to the SMU sites and selected remedy are described below.

2.12.2.1 Chemical-Specific ARARs

- Federal Safe Drinking Water Act, National Primary Drinking Water Regulations (40 CFR Part 141) – Establishes primary drinking water standards such as MCLs. The selected remedy will attain the quantitative groundwater RAOs described in Section 2.7 and listed in Table 6. These quantitative RAOs are based on the federal MCLs for the COCs at each site.

- Chapter 91, Delaware HSCA (1995), the Delaware Regulations Governing HSCA and the Remediation Standard Guidance – Establishes risk-based and chemical-specific remediation standards applicable to sites where hazardous substances have been released. State risk-based remediation standards require that the cumulative cancer risk from all contaminants at a site not exceed 1×10^{-5}, and cumulative non-cancer health risks not exceed 1. Delaware chemical-specific remediation standards established under HSCA are equivalent to federal MCLs for the COCs in groundwater at the SMU sites. The selected remedy will attain the quantitative groundwater RAOs listed in Table 6, which will satisfy State risk-based and chemical-specific remediation standards.

2.12.2.2 Action-Specific ARARs

- Federal Safe Drinking Water Act, Underground Injection Control (UIC) (40 CFR Parts 144 and 146) and the substantive requirements of the Delaware Regulations

Governing Underground Injection Control – Establishes technical criteria and standards for underground injection. Application of the AB technology at SS07/Area 2 involves underground injection of a carbon substrate which will be accomplished in accordance with UIC requirements.

- Delaware Regulations Governing the Construction and Use of Wells (1997) – Establishes requirements for the location, design, installation, use, modification, repair, and abandonment of groundwater wells and associated equipment. Wells installed under the selected remedy will comply with these regulations.

- Delaware Regulations Governing Hazardous Waste (DRGHW), Groundwater Protection (DRGHW Part 264.b Subpart F) – Establishes groundwater monitoring criteria. The selected remedy includes groundwater monitoring at all four of the SMU sites.

2.12.2.3 Location-Specific ARARs

- Requirements for Wetlands and Floodplains (40 CFR Part 6 – National Environmental Policy Act §6.302) – Establishes requirements to avoid adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. This ARAR is applicable to Sites FT01 and LF18/Area 9 which are adjacent to wetlands and are located in a 100-year floodplain. The selected remedy will not adversely affect the wetland or floodplain areas.

2.12.3 Cost-Effectiveness

In the USAF's judgment, the selected remedy is cost-effective and represents a reasonable value for the money to be spent. According to NCP §300.430(f)(1)(ii)(D), a remedy is considered cost effective if its "costs are proportional to its overall effectiveness." The overall effectiveness of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant) was evaluated by assessing three of the five balancing criteria used in the analysis of alternatives: long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness. Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of the selected remedy was determined to be proportional to its costs and hence this alternative represents a reasonable value for the money to be spent.

Table 13 summarizes the cost-effectiveness determination for the selected remedy. The estimated present worth cost of the selected remedy is $1,800,000. This includes the capital costs as well as the O&M costs estimated over the length of time required to achieve RAOs at each site. Although Alternatives A2 and A7 are less expensive, the time to achieve RAOs with Alternative A2 is significantly higher for SS07/Area 2, and

Table 13. Cost and Effectiveness Matrix for SMU Remediation Options

Relevant Considerations for Cost Effectiveness Determination:
(1) Groundwater contaminant plumes exist at each of the four SMU sites, some are close to or at the Base boundary.
(2) The primary factor for differentiating cost is the method of source treatment, which is most relevant to short-term effectiveness. Distal plume treatment options are limited due to the generally low levels of contamination over relatively large areas.
(3) Limited soil contamination is present at one site (LF18). LUCs will restrict exposure and are a component of each alternative except A1 - No Action.

Alternative	Cost Effective?	Present Worth Cost	Incremental Cost	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness
A1 - No Action	No	$0	$0	Alternative provides no mechanism to determine reduction in long-term risks to human health or the environment.	No reduction in toxicity. No reduction in mobility. No reduction in volume.	*No short-term risks to workers, community, or environment. *Time to achieve RAOs is unknown with this alternative.
A7 - Accelerated Bioremediation	Yes	$1,400,000	$1,400,000	(1) All action alternatives are long-term and permanent solutions for groundwater contamination. (2) LUCs are effective in restricting exposures as required by the soil and groundwater RAOs (see Section 2.7). (3) LUCs will remain in place until land uses change or until contaminant levels fall below the levels allowing for unrestricted or unlimited use.	Reductions in toxicity and volume of contaminants are achieved with all seven action alternatives except for the following alternative-site combinations: A4 - LF17 & FT01 A6 - LF18/Area 9 A7 - LF18/Area 9	= No short-term risks to workers, community, or environment. + Source control achieved in 7 to 20 years at LF17, SS07/Area 2, and FT01. = Unsuitable for LF18/Area 9.
A2 - Natural Attenuation	Yes	$1,550,000	$150,000			= No short-term risks to workers, community, or environment. - Source control achieved in 12 to 31 years at LF17, SS07/Area 2, and FT01. + Suitable for LF18/Area 9, source control achieved in 25 years at this site.
A8 - AB & Natural Attenuation	Yes	$1,800,000	$250,000			= No short-term risks to workers, community, or environment. + Source control achieved in 7 to 25 years at LF17, SS07/Area 2, FT01, and LF18/Area 9.
A6 - Chemical Oxidation	Yes	$2,280,000	$480,000			= No short-term risks to workers, community, or environment. + Most quickly achieves source control, on the order of one year, but with little effect on distal plumes. - Unsuitable for LF18/Area 9.
A3 - UVB	Yes	$7,440,000	$5,160,000			= No short-term risks to workers, community, or environment. = Very quickly achieves source control, approximately 2 to 5 years, but with little effect on distal plumes. - Unsuitable for source control LF18/Area 9.
A5 - Groundwater Extraction & Air Stripping	Yes	$7,630,000	$190,000			= No short-term risks to workers, community, or environment. - Slower times to achieve source control, similar to A2 Natural Attenuation.
A4 - PRB	Yes	$18,780,000	$11,150,000			= No short-term risks to workers, community. or environment. = Slower times to achieves source control, similar to A2 Natural Attenuation. - Unsuitable for FT01.

Cost Effectiveness Summary:
(1) All seven action alternatives (A2 through A8) are cost effective.
(2) The two most aggressive options (A3 and A6) achieve RAOs in the source areas very rapidly but do not result in significant reductions in downgradient remediation times, and they are very costly.
(3) A2, A4, and A5 provide the least rapid source remediation times because they rely on natural groundwater flow to transport contaminants for treatment. A4 and A5 are the most costly alternatives.
(4) A7 provides little added benefit to LF17 and FT01 over natural attenuation (A2) alone and is not suitable for LF18/Area 9.
(5) A8 combines the best of alternatives A2 and A7. Overall plume remediation times are comparable to other alternatives, with a particular improvement of the remediation time for the SS07/Area 2 source area (7 years).

Key:
* Baseline characteristic
+ More effective than previous alternative
- Less effective than previous alternative
= No change compared to previous alternative

A7 does not address groundwater contamination at LF18/Area 9. The USAF believes that the selected remedy (A8, AB and Natural Attenuation with Monitoring) will provide an overall level of protection comparable to other alternatives at significantly lower cost.

2.12.4 Use of Permanent Solutions and Alternative Treatment Technologies

The USAF has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be practicably used at the SMU sites. Of those alternatives that are protective of human health and the environment and comply with ARARs, the USAF has determined that the selected remedy (AB, Natural Attenuation with Monitoring, and LUCs) provides the best balance of tradeoffs in terms of the five balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume of contaminants through treatment; short-term effectiveness; implementability; and cost) while also considering the statutory preference for treatment as a principal element, the bias against off-site treatment and disposal, and considering regulatory and community acceptance.

All of the evaluated alternatives except No Action (A1) would provide excellent performance relative to the criteria of long-term effectiveness and permanence and reduction of toxicity, mobility or volume through treatment. All alternatives except No Action involve the permanent reduction of groundwater contaminant levels through treatment. Therefore, the most decisive criteria in evaluating the best balance of tradeoffs are short-term effectiveness, implementability, and cost. The selected remedy provides the best blend of these criteria, providing good short-term effectiveness by reducing groundwater contaminant levels, being readily implementable, and costing much less while still providing good remediation times relative to other alternatives.

2.12.5 Preference for Treatment as a Principal Element

The selected remedy somewhat satisfies the statutory preference for treatment as a principal element of the remedy. There are no source materials constituting principal threats at the four SMU sites. The selected remedy satisfies the statutory preference for treatment by applying a groundwater treatment remedy at Site SS07/Area 2. Groundwater source areas within the SS07/Area 2 plume will be treated using AB. The remaining plumes will be addressed via natural attenuation. These groundwater remedies are expected to reduce the toxicity, mobility, and volume of the groundwater contaminants to levels meeting ARARs.

2.12.6 Five-Year Review Requirements

Because the selected alternative will result in hazardous substances remaining on-site above levels that allow for unrestricted exposure and unlimited use, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

ORIGINAL

2.13 DOCUMENTATION OF SIGNIFICANT CHANGES TO THE SELECTED REMEDY FROM THE PREFERRED ALTERNATIVE OF THE PROPOSED PLAN

The Proposed Plan for the SMU was released for public comment in February 2005. The Proposed Plan identified Alternative A8 – AB, Natural Attenuation with Monitoring, and LUCs – as the preferred alternative for the SMU sites. No written or verbal comments were received during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

PART III: RESPONSIVENESS SUMMARY

The Proposed Plan for SMU Sites LF17, SS07/Area 2, FT01, and LF18/Area 9, Dover Air Force Base, Delaware (USACE, 2005b), was made available to the public for review and comment from February 13, 2005 through March 14, 2005. No written or oral comments were received from the community during the public comment period, and no request for a public meeting was received. No regulatory agency or legal issues have been identified. This ROD documents the selected remedy with no changes from the Proposed Plan.

ATTACHMENT 1 - REFERENCES

ORIGINAL

BWXT, 2003. Five-Year Reviews: LF18 Soil; FT03 Structures/Soil and Groundwater; WP14/LF15 Groundwater; LF13 Groundwater, submitted by URS Group Inc., September 2003.

USACE, 2005a. Final Feasibility Study [and Addendum: Plume Delineation and Assessment of Natural Attenuation], South Management Unit, Dover Air Force Base, Delaware, submitted by URS Group, Inc., January 2005.

USACE, 2005b. Proposed Plan South Management Unit, Dover AFB, Delaware, January 2005

USACE, 2000. Basewide Ecological Risk Assessment, Dover Air Force Base, Delaware, submitted by Dames & Moore, March 2000.

USACE, 1999. Post Excavation Report, Site LF18, Dover Air Force Base, Delaware, prepared by U.S. Army Corps of Engineers, Omaha District, May 1999.

USACE, 1997. Basewide Remedial Investigation, Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, August 1997. [South Management Unit, Volumes I - IV]

USACE, 1996. Final Engineering Evaluation and Cost Analysis, Site LF18, Dover AFB, Delaware, submitted by Dames & Moore, June 1996

USAF, 1996. U.S. Air Force Record of Decision, Site LF18, Dover Air Force Base, Dover, Delaware, September 1996.

USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening, USEPA Region III, EPA/903/R-93-001, January 1993.

USEPA, 1991. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, OSWER 9355.0-30, April 1991.

USGS, 2002. Data Letter for LF18 Groundwater Samples, submitted to Dover Air Force Base, Delaware April 2002.

USGS, 1999. Data Letter for FT01 Groundwater Samples, Summer 1998, submitted to Dover Air Force Base, Delaware on February 9, 1999.

USGS, 1998. Data Letter for LF18 Soil Samples, Summer/Fall 1998, submitted to Dover Air Force Base, Delaware on December 23, 1998.

ATTACHMENT 2

ARARs

TABLE 2a. Federal ARARs

Environmental Laws and Regulations	Consideration as an ARAR	Site Applicability	Remedial Alternative Applicability	Status (1)
Title 40 – Protection of Environment, Chapter I – Environmental Protection Agency, Resource Conservation and Recovery Act (RCRA), Subchapter I – Solid Wastes				
1. Part 264 – Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities				
a. Groundwater Protection (Subpart F)	Groundwater monitoring should be conducted in accordance with substantive monitoring criteria.	All*	All**	R/A
264.91 – Required programs	Requires owners and operators to conduct groundwater monitoring and response program.			
264.92 – Groundwater protection standard	Requires a groundwater protection standard be established in the facility permit when hazardous constituents have been detected in groundwater.			
264.93 – Hazardous constituents	Requires the hazardous constituents that have been detected in groundwater in at least the uppermost aquifer underlying a regulated unit and that are reasonably expected to be in or derived from waste contained in a regulated unit to be identified in the facility permit.			
264.94 – Concentration limits	Establishes the concentration limits in the groundwater for the hazardous constituents identified in 264.93.			
264.95 – Point of compliance	Requires the point of compliance at which the groundwater protection standard applies and at which monitoring must be conducted.			
264.96 – Compliance period	Requires a compliance period during which the groundwater protection standard applies.			
264.97 – General groundwater monitoring requirements	Requires a groundwater monitoring system must contain a sufficient number of wells, installed at reasonable locations and depths. Requires the wells to be installed properly. Requires a groundwater monitoring program with consistent sampling and analysis procedures that will provide a reliable indication of groundwater quality below the waste management area.			
264.98 – Detection monitoring program	Requires that the owner or operator establish a detection monitoring program, which shall include indicator parameters, waste constituents, or reaction products that provide a reliable indication of the presence of hazardous constituents in groundwater.			
264.99 – Compliance monitoring program	Requires a compliance monitoring program be established to determine whether regulated units are in compliance with the groundwater protection standard.			
264.101 – Corrective action for solid waste management units	Requires corrective action to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit at the facility, regardless of the time at which waste was placed in the unit.			

(1) A = Applicable R/A = Relevant and Appropriate TBC = To Be Considered

*All – includes sites LF17, SS07/Area 2, FT01, and LF18/Area 9

**All – includes all seven action alternatives A2 through A8

TABLE 2a. Federal ARARs (cont'd)

Environmental Laws and Regulations	Consideration as an ARAR	Site Applicability	Remedial Alternative Applicability	Status (1)
b. Land Treatment (Subpart M)	*In Situ* treatment technologies may be considered land treatment.	All*	All**	R/A
264.271 – Treatment program	Requires the land treatment program be designed to ensure that hazardous constituents placed in or on the treatment zone are degraded, transformed, or immobilized within the treatment zone.			
264.273 – Design and operating requirements	Requires that the land treatment unit be designed, constructed, operated, and maintained to maximize the degradation, transformation, and immobilization of hazardous constituents in the treatment zone.			
264.280 – Closure and post-closure care	Requires that during the closure period, all operations necessary to maximize degradation, transformation, or immobilization of hazardous constituents within the treatment zone continue.			
2. Part 257 – Criteria for Classification of Solid Waste Disposal facilities and Practices	Solid waste disposal facilities or practices which violate any of the following criteria pose a reasonable probability of adverse effects on health or the environment: floodplains, endangered species, surface water, groundwater, food chain crops, disease, air and safety.	LF17 & LF18	All**	R/A
3. Part 258 – Criteria for Municipal Solid Waste Landfills	This regulation establishes minimum national criteria under RCRA for all new and existing municipal solid waste landfill units, and all other solid waste disposal facilities that are not regulated under subtitle C of RCRA. These criteria do not apply to municipal solid waste landfill units that do not receive waste after October 9, 1991.	LF17 & LF18	All**	R/A
a. Closure and Post-Closure Care (Subpart F)				
258.61 – Post-closure care requirements	The integrity of any final cover system must be maintained to correct the effects of settlement, subsidence, erosion, or other events, and prevent run-on or run-off from damaging the final cover.			
Safe Drinking Water Act (SDWA)				
1. Part 144- Underground Injection Control	Extracted groundwater may be reinjected under some remedial alternatives.	All*	A6, A7, A8	A
2. Part 146 – Underground injection control program: Criteria and standards	Identifies technical criteria and standards for the UIC Program.			
3. Part 141 – National primary drinking water regulations	Establishes primary drinking water regulations pursuant to the SDWA such as maximum contaminant levels (MCLs). Some constituents exceed their MCLs in groundwater.	All*	All**	R/A
4. Part 142 – National primary drinking water regulations implementation	Identifies regulations for the implementation and enforcement of the national primary drinking water regulations.			
5. Part 143 – National secondary drinking water regulations	Establishes the National Secondary Drinking Water Regulations of the SDWA. These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. These regulations are not Federally enforceable but are intended as guidelines for the States.			

(1) A = Applicable R/A = Relevant and Appropriate TBC = To Be Considered

*All – includes sites LF17, SS07/Area 2, FT01, and LF18/Area 9

**All – includes all seven action alternatives A2 through A8

TABLE 2a. Federal ARARs (cont'd)

Environmental Laws and Regulations	Consideration as an ARAR	Site Applicability	Remedial Alternative Applicability	Status (1)
Clean Air Act (CAA) Part 50 – National Primary and Secondary Ambient Air Quality Standards	Groundwater treatment alternatives may involve emissions to air. National ambient air quality standards define levels of air quality which the Administrator judges are necessary, with an adequate margin of safety, to protect the public health.	All*	A3, A5	A
Part 6 – Procedures for Implementing the Requirements of the Council on Environmental Quality on the National Environmental Policy Act (NEPA)	Scientific, historic, or archaeological sites are located in the vicinity of the site. Consultations with State Historic Preservation officials have been made.	All*	All**	A (NEPA) TBC (Exec Orders)
6.301(a) – Historic Sites Act of 1935, 15 U.S.C. 461-467				
6.301(b) – National Historic Preservation Act and Executive Order 11593, 16 U.S.C. 470, 36 CFR 800				
6.301(c) – Archaeological and Historic Preservation Act of 1974, 16 U.S.C. 469				
6.302 – Wetlands, floodplains, important farmlands, coastal zones, wild and scenic rivers, fish and wildlife, and endangered species.	This subsection of NEPA and supporting executive orders require Federal agencies conducting certain activities to avoid adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. Executive Order 11988, Floodplain Management, requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid adverse effects associated with direct and indirect development of a floodplain.	FT01 & LF18	All**	A (NEPA) TBC (Exec Orders)
Federal Water Pollution Control Act ("Clean Water Act")				
Title 3 - Standards and Enforcement	Requires the establishment of water quality criteria: National Recommended Water Quality Criteria (November 2002)	All*	A5	A

(1) A = Applicable R/A = Relevant and Appropriate TBC = To Be Considered

*All – includes sites LF17, SS07/Area 2, FT01, and LF18/Area 9

**All – includes all seven action alternatives A2 through A8

TABLE 2b. State ARARs

Environmental Laws and Regulations	Consideration as an ARAR	Site Applicability	Remedial Alternative Applicability	Status (1)
A. Delaware Solid Waste Disposal Regulations (DNREC Regulations Governing Solid Waste) 1. Section 6: Industrial Landfills		LF17 & LF18	All**	R/A
a. Capping	Requires installation of a cap upon closure of a landfill that will promote the establishment of vegetative cover, minimize infiltration, and prevent erosion of waste throughout the post-closure care period. Capping system shall include a final grading layer on the waste, and impermeable layer, and a final cover..			
b. Closure	Requires the closed landfill to minimize the need for further maintenance and the post-closure escape of solid waste constituents, leachate, and landfill gases to the surface water, groundwater, or atmosphere.			
c. Post-Closure Care	Minimum post-closure care requirements include maintaining the following: the integrity and effectiveness of the capping system; the groundwater monitoring system, and the surface water management system.			
B. Delaware Hazardous Waste Management Regulations (DNREC Regulations Governing Hazardous Waste (DRGHW)) 1. DRGHW Part 264 Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal				
a. Groundwater Protection (Subpart F)	Groundwater monitoring should be conducted in accordance with substantive monitoring criteria.	All*	All**	R/A
264.91 – Required programs	Requires owners and operators to conduct groundwater monitoring and response program.			
264.92 – Groundwater protection standard	Requires a groundwater protection standard be established in the facility permit when hazardous constituents have been detected in groundwater.			
264.93 – Hazardous constituents	Requires the hazardous constituents that have been detected in groundwater in at least the uppermost aquifer underlying a regulated unit and that are reasonably expected to be in or derived from waste contained in a regulated unit to be identified in the facility permit.			
264.94 – Concentration limits	Establishes the concentration limits in the groundwater for the hazardous constituents identified in 264.93.			
264.95 – Point of compliance	Requires the point of compliance at which the groundwater protection standard applies and at which monitoring must be conducted.			
264.96 – Compliance period	Requires a compliance period during which the groundwater protection standard applies.			

(1) A = Applicable R/A = Relevant and Appropriate
*All – includes sites LF17, SS07/Area 2, FT01, and LF18/Area 9
**All – includes all seven action alternatives A2 through A8

TABLE 2b. State ARARs (cont'd)

Environmental Laws and Regulations	Consideration as an ARAR	Site Applicability	Remedial Alternative Applicability	Status (1)
264.97 – General groundwater monitoring requirements	Requires a groundwater monitoring system must contain a sufficient number of wells, installed at reasonable locations and depths. Requires the wells to be installed properly. Requires a groundwater monitoring program with consistent sampling and analysis procedures that will provide a reliable indication of groundwater quality below the waste management area.			
264.98 – Detection monitoring program	Requires that the owner or operator establish a detection monitoring program, which shall include indicator parameters, waste constituents, or reaction products that provide a reliable indication of the presence of hazardous constituents in groundwater.			
264.99 – Compliance monitoring program	Requires a compliance monitoring program be established to determine whether regulated units are in compliance with the groundwater protection standard.			
264.101 – Corrective action for solid waste management units	Requires corrective action to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit at the facility, regardless of the time at which waste was placed in the unit.			
b. Land Treatment (Subpart M)	*In Situ* treatment technologies may be considered land treatment.	All*	All**	R/A
264.271 – Treatment program	Requires the land treatment program be designed to ensure that hazardous constituents placed in or on the treatment zone are degraded, transformed, or immobilized within the treatment zone.			
264.273 – Design and operating requirements	Requires that the land treatment unit be designed, constructed, operated, and maintained to maximize the degradation, transformation, and immobilization of hazardous constituents in the treatment zone.			
264.280 – Closure and post-closure care	Requires that during the closure period, all operations necessary to maximize degradation, transformation, or immobilization of hazardous constituents within the treatment zone continue.			
C. Delaware Water Pollution Control Acts				
1. Regulations Governing the Control of Water Pollution				
Section 4, Part II – Discharges Subject to the Requirements of the National Pollutant Discharge Elimination System (NPDES)	Discharges to surface water will have to meet the intent of NPDES permit requirements.	All*	A5	A
Section 8 - Industrial Waste Effluent Limitations	Effluents generated by site remedial activities may require pretreatment. Any effluent discharge to publicly owned treatment works (POTWs) must meet pretreatment standards, however, the discharge of groundwater to POTWs is generally prohibited by municipal sewer authorities.	All*	A5	A
2. Delaware Water Quality Standards (DNREC Surface Water Quality Standards)	Remedial alternatives resulting in discharge to surface water may affect water quality.	All*	A5	A
3. Delaware Underground Injection Regulations (DRGUIC parts 122, 124 and 146.)	Treatment chemicals and extracted groundwater may be reinjected under some remedial alternatives.	All*	A6, A7, A8	A

(1) A = Applicable R/A = Relevant and Appropriate

*All – includes sites LF17, SS07/Area 2, FT01, and LF18/Area 9

**All – includes all seven action Alternatives A2 through A8

TABLE 2b. State ARARs (cont'd)

Environmental Laws and Regulations	Consideration as an ARAR	Site Applicability	Remedial Alternative Applicability	Status (1)
Part 122 – State Administered Underground Injection Control Program	Defines the regulatory framework of State administered permit programs.			
Part 124 – Procedures for Decision Making	Describes the procedures the Agency will use for issuing permits under the program.			
Part 146 – Underground Injection Control Program: Criteria and Standards	Describes the technical criteria and standards for the Underground Injection Control Program.			
D. **Delaware Air Quality Standards (DNREC Air Quality Regulations)**	Groundwater treatment alternatives may involve emissions to air.	All*	A3, A5	A
E. **Delaware Code Annotated, Title 7 – Conservation, (Chapter 40 Erosion and Sedimentation)**	Alternatives resulting in the disturbance of soil will require measures to control erosion.	All*	All**	A
F. **Delaware Regulations Governing the Construction and Use of Wells (1997)**	Applies to the location, design, installation, use, modification, repair, and abandonment of wells and associated equipment.	All*	All**	A
G. **Chapter 91, Delaware Hazardous Substance Cleanup Act (HSCA; 1995) and the Delaware Regulations Governing HSCA and the Remediation Standard Guidance**	Requires a facility to identify, investigate and clean up sites with a release or imminent threat of release of hazardous substances. Such conditions are present at the sites addressed by this ROD.	All*	All**	R/A

(1) A = Applicable R/A = Relevant and Appropriate

*All – includes sites LF17, SS07/Area 2, FT01, and LF18/Area 9

**All – includes all seven action Alternatives A2 through A8